MTS Temposonics®
Linear Position Sensors

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Temposonics®

Position Sensors and Systems

Temposonics® II
Position Sensors

Installation & Instruction Manual

11-98 550055 Revision E

GENERAL INFORMATION

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1. Introduction to the Temposonics II Linear Displacement Transducer (LDT)

The Temposonics™II Linear Displacement Transducer precisely senses the position of an external magnet to measure displacement with a high degree of resolution. The system measures the time interval between an interrogation pulse and a return pulse. The interrogation pulse is transmitted through the transducer waveguide, and the return pulse is generated by a movable permanent magnet representing the displacement to be measured.

1.1 Theory of Operation/Magnetostriction

The interrogation pulse travels the length of the transducer by a conducting wire threaded through the hollow waveguide. The waveguide is spring loaded within the transducer rod and exhibits the physical property of magnetostriction. When the magnetic field of the interrogation pulse interacts with the stationary magnetic field of the external magnet, a torsional strain pulse or "twist" is produced in the waveguide. This strain pulse travels in both directions, away from the magnet. At the end of the rod, the strain pulse is damped within the "dead zone". At the head of the transducer, two magnetically coupled sensing coils are attached to strain sensitive tapes. The tapes translate the strain pulse through coils to an electrical "return pulse". The coil voltage is then amplified in the head electronics before it is sent to various measuring devices as the conditioned "return pulse". See the Temposonics II Analog and Digital manuals for more information on analog and digital system configurations.

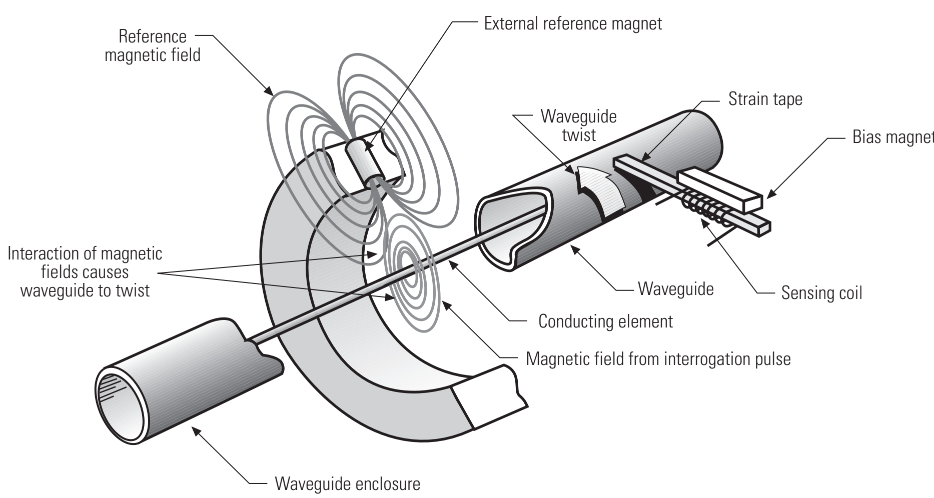


Figure 1-1
Waveguide Interaction

1.2 Temposonics II LDT Specifications for Sensors <180 Inches

Parameter	*Specifications*
Input Voltage:	± 12 to ± 15 Vdc
Current Draw:	Transducer Only: ± 15 Vdc at 100 mA maximum, 25 mA minimum (current draw varies with magnet position, maximum draw occurs when magnet is at 2 in. (50.6 mm) from the flange and minimum update time is being utilized)
Displacement:	Up to 25 feet (7620 millimeters)
Dead Zone:	2.5 inches (63.5 millimeters)
Electronics Enclosure:	IP-67
Non-linearity:	< ± 0.05% of full scale or ± 0.002 inch (±0.05 mm), whichever is greater
Repeatability:	< ± 0.001% of full scale or ± 0.0001 inch (±0.002 mm), whichever is greater
Hysteresis:	0.0008 inch (0.02 mm) maximum
Temperature Coefficient: Transducer (length dependent): Electronics:	 3 ppm/°F (5.4 ppm/°C) <0.00011 in./°F (<0.00503 mm/°C)
Operating Temperature: Head Electronics: Transducer Rod:	 - 40 to 150°F (- 40 to 66°C) - 40 to 185°F (- 40 to 85°C)
Operating Pressure:	3000 psi continuous, 8000 psi static
Output Impedance:	47Ω

Specifications are subject to change without notice. Consult MTS for verification of specifications critical to your application.

1.3 Temposonics II LDT Specifications for Sensors ≥180 Inches

Below is a list of specifications that pertain to Temposonics II transducers with active stroke lengths of 180 inches (4572 mm) to 300 inches (7620 mm). The below specifications apply only to sensors 180 to 300 inches in length. Specifications not listed below may be found in section 1.2, above.

Parameter	*Specifications*
Input Voltage:	• Maximum: ± 15 Vdc, ± 5% at 100 mA • Minimum: ± 15 Vdc at 25 mA (current draw varies with magnet position, maximum draw occurs when magnet is 2 inches (50.8 mm) from the flange and minimum update time is being used)
Dead Zone:	3 in. (76.2 mm)
Cable Length:	• Maximum cable length for neuter version transducer (i.e., Temposonics II without an integrated Personality Module) which requires the use of external interface electronics (Analog Output Module, Digital Interface Box or other signal conditioners) is 250 ft.
Magnet Requirement:	Part Numbers: 201554, 201553, 251416, 201542

2. Temposonics II LDT Installation

Before beginning installation, be sure you know the following dimensions (as illustrated in Figures 2-1 to 2-3a-c.):

- Null Space
- Stroke
- Dead Zone

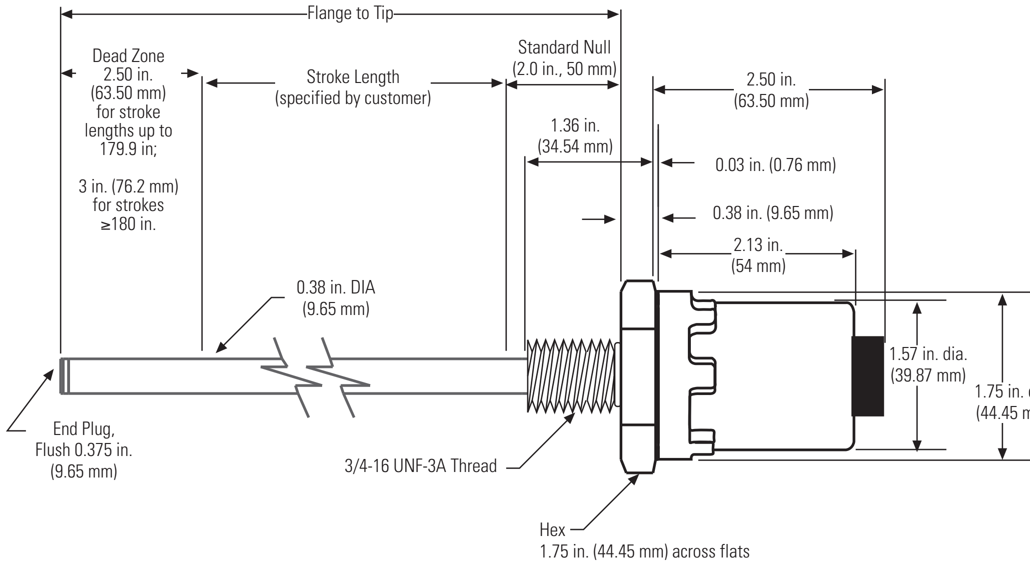


Figure 2-1
Temposonics II Dimensions

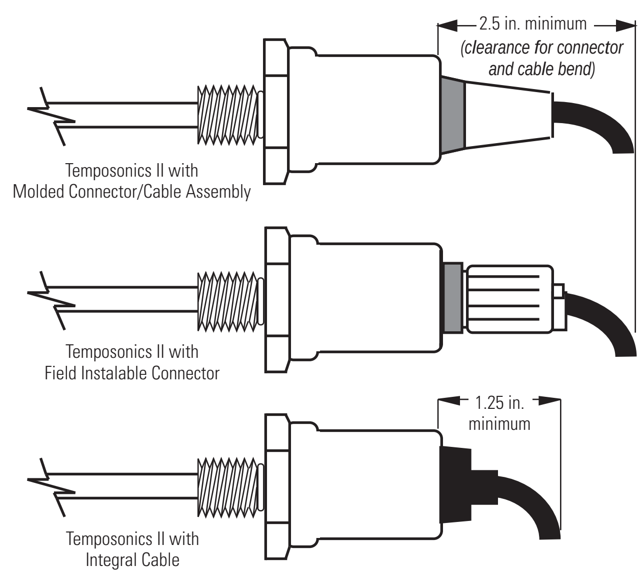


Figure 2-2
Temposonics II Connector/Cable Clearance Requirements

1. Use the 3/4 inch (19 mm), 16 UNF thread of the transducer to mount it at the selected location. Leave room to access the hex head. If a pressure or moisture seal is required, install an O-ring (type MS 28778-8 is recommended) in the special groove. Use the hex head to tighten the transducer assembly.

2. Install the permanent magnet over the LDT rod. Mount the permanent magnet to the movable device whose displacement will be measured. To minimize the effect of magnetic materials (i.e. iron, steel, etc.) on the magnetic field of the permanent magnet, ensure the minimum spacing requirements are met as shown in Figure 2-3a-c. (Any non-magnetic materials can be in direct contact with the permanent magnet without affecting performance.)

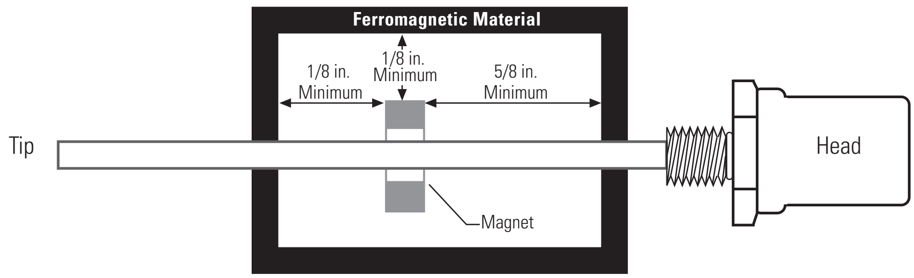


Figure 2-3a
Minimum Magnet Clearance Using Magnetic Supports

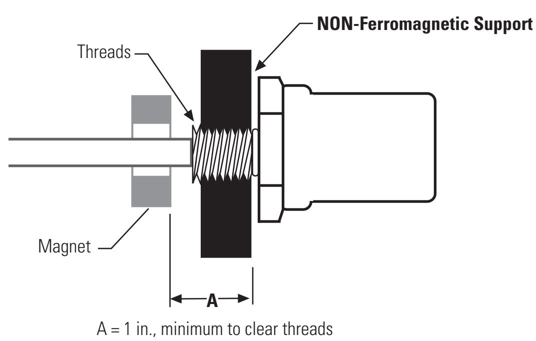


Figure 2-3b
Minimum Null Space Using Non-Magnetic Support

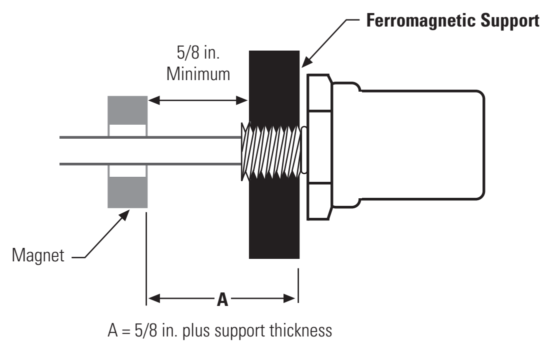


Figure 2-3c
Minimum Null Space Using Magnetic Support

Notes:
1. The magnet must not contact ferromagnetic materials (such as iron or steel). Clearances are required between the surface of the magnet and ferromagnetic material, as shown. Non-ferrous material (such as copper, brass, or 300 series stainless steel) may contact the magnet without affecting transducer performance.
2. Standard Null Space is 2 inches. There is no maximum limit for Null Space. Less then 2 inches can be specified if magnet clearances meet requirements illustrated above.

> **NOTE:**
>
> *Clearance between the magnet and the transducer rod is not critical. However, contact between the components will cause wear over time. The installation of supports or readjustment of the supports is recommended if the magnet contacts the transducer rod.*

3. Move the permanent magnet full-scale to check that it moves freely and does not rub against the transducer. If the magnet does not move freely, you can correct this by mounting a support bracket to the end of the tranducer. Long transducers may need additional supports to be attached to the transducer rod. Transducer supports are described later in this section.

2.1 Types of Transducer Supports

Long transducers (48 inches or longer) may require supports to maintain proper alignment between the transducer rod and the permanent magnet. When transducer rod supports are used, special, open-ended permanent magnets are required.

Transducer supports attached to the active stroke length must be made of a non-ferrous material, thin enough to permit the permanent magnet to pass without obstruction. Because the permanent magnet does not enter the dead zone, supports connected within the dead zone may be made of any material. The main types of supports are loop, channel, and guide pipe supports.

2.1.1 Loop Supports

Loop supports are fabricated from non-ferrous materials, thin enough to permit free movement of the magnet. Loop supports are recommended for straight transducers and may be spaced apart approximately every three feet. They may be used alone or with channel supports. Figure 2-4 illustrates the fabrication of a loop support.

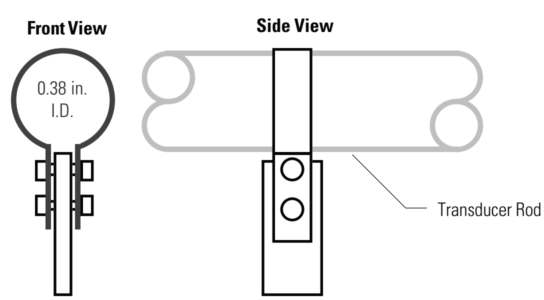


Figure 2-4
Loop Support

> **NOTE:**
>
> *When open magnets are used, ensure the transducer rod remains within the inside diameter of the magnet throughout the length of the stroke. If the transducer rod is allowed to enter the cut out area of an open magnet, the transducer signal could attenuate or be lost. See Figure 2-7.*

2.1.2 Channel Supports

Channel supports, being typically straight, are normally used with rigid transducers. A channel support consists of a straight channel with loop supports mounted at intervals. The loop supports are required to keep the transducer within the channel. Figure 2-5 shows a channel support. Channel supports are available from various manufacturers or may be fabricated.

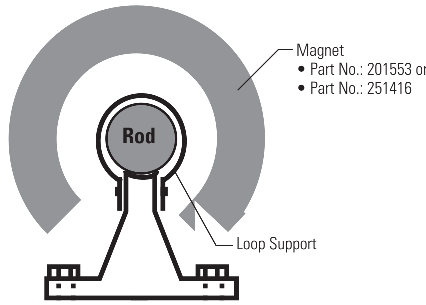


Figure 2-5
Channel Support

2.1.3 Guide Pipe Supports

Guide pipe supports are normally used for flexible transducers. A guide pipe support is constructed of non-ferrous material, straight or bent to the desired shape. As shown in Figure 2-6, both inside and outside dimensions of the pipe are critical:

- Because the transducer rod is installed inside the pipe, the inside diameter of the pipe must be large enough to clear the rod.

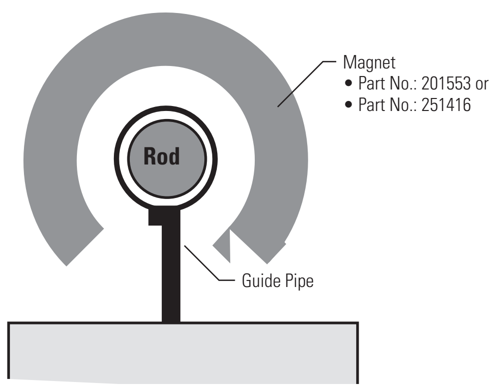


Figure. 2-6
Guide Pipe Support

- The outside diameter of the pipe must be small enough to clear the magnet.

Refer to pipe manufacturers' specifications and dimensions (schedule 10, 40, etc.) to select the appropriate size pipe. Guide pipe is typically supported at each end of the pipe.

2.2 Open Magnets

When using an open magnet, make sure the rod is positioned at all times within the “active” zone of the magnet. The transducer cannot operate properly unless the entire stroke of the transducer rod is located within this zone. The active zone, as shown in Figure 2-7, lies within the inside diameter of the magnet.

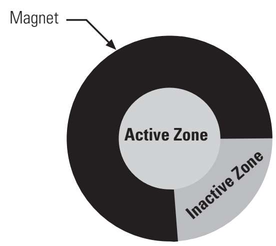


Figure 2-7
Active Zone for Open Magnets

2.3 Spring Loading or Tensioning

The transducer rod can be spring loaded or tensioned using a stationary weight. Attach a spring mechanism or weight to the dead zone of the transducer rod with a clamping device which will not deform the transducer rod. The maximum weight or spring tension is 5 to 7 lbs.

2.4 Cylinder Installation

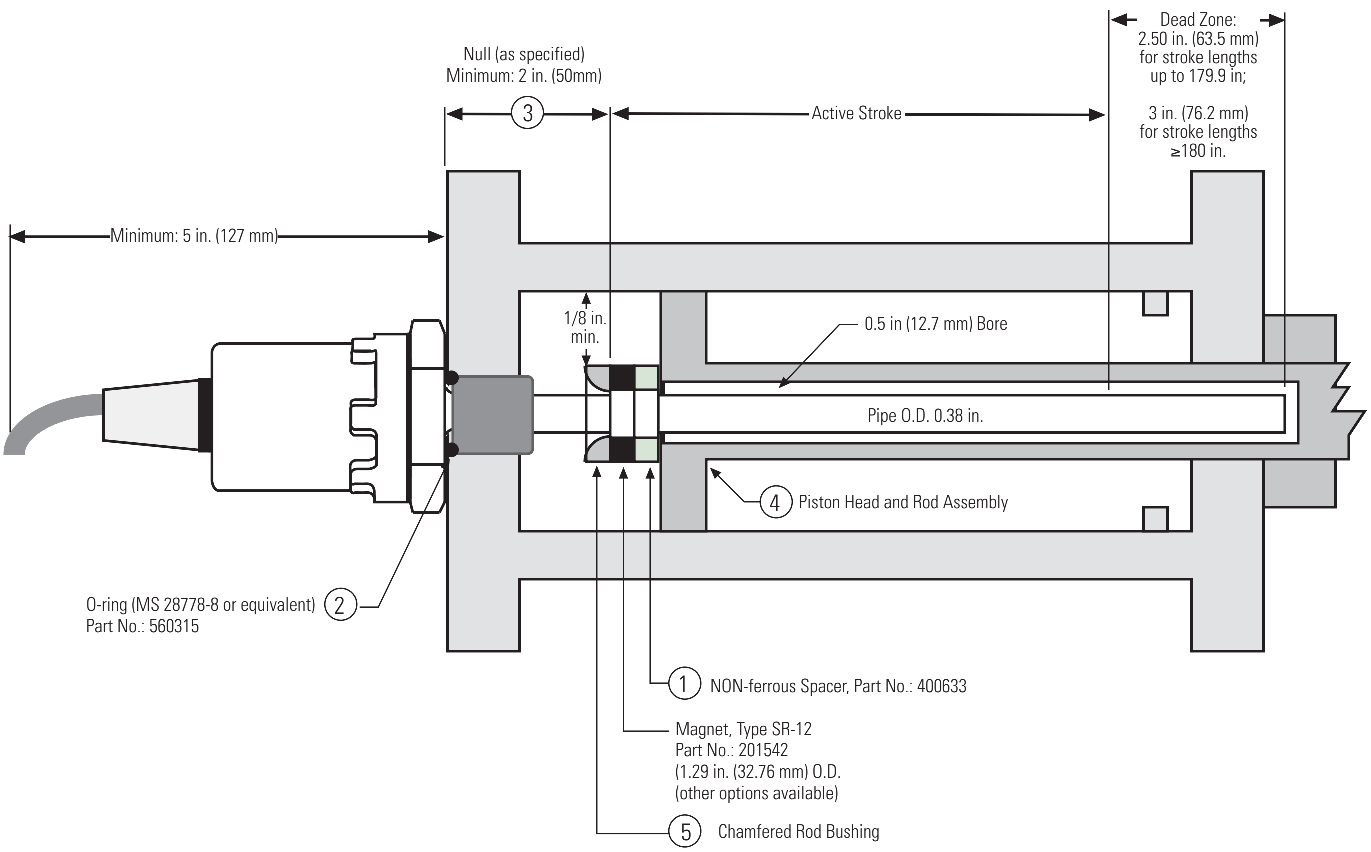
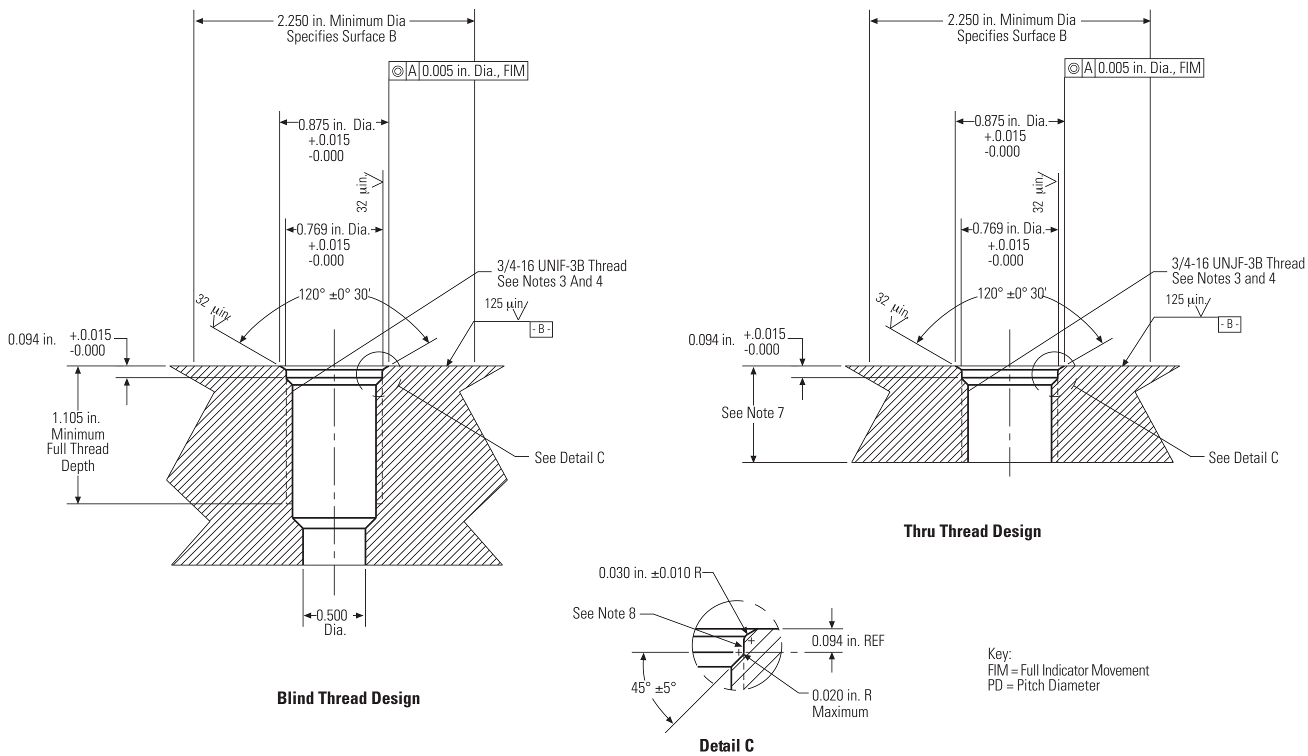


Figure 2-8
Typical Cylinder Installation

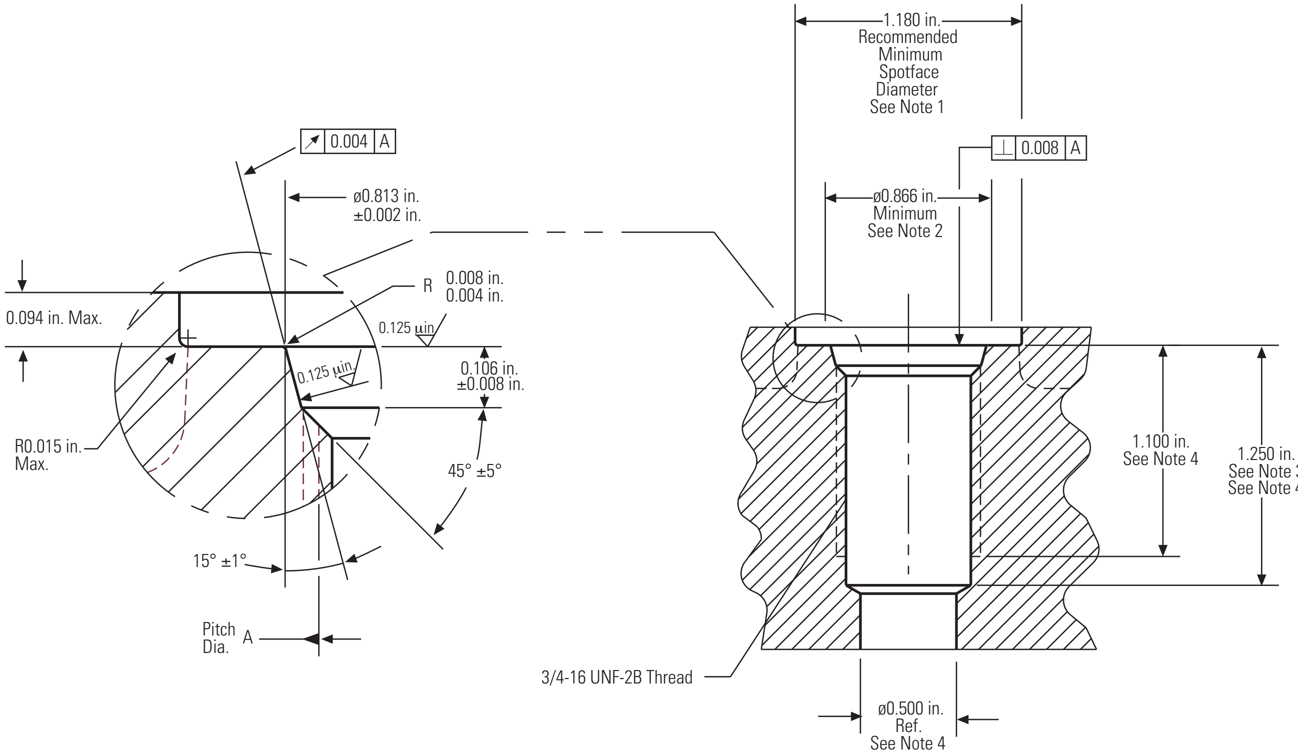
Figure 2-8 shows a typical cylinder installation. Review the following before attempting this type of installation.

- Use a non-ferrous (plastic, brass, Teflon®, etc.) spacer [1] to provide 1/8 inch (32 mm) minimum space between the magnet and the piston.
- An O-ring groove [2] is provided at the base of the transducer hex head for pressure sealing. MTS uses mil-standard MS33514 for the O-ring groove. Refer to mil-standard MS33649 or SAE J514 for machining of mating surfaces.
- The null space [3] is specified according to the installation design and cylinder dimensions. The analog output module provides a null adjustment. Make sure that the magnet can be mounted at the proper null position.
- The piston head [4] shown in Figure 2-8 is typical. For some installations, depending on the clearances, it may be desired to countersink the magnet.
- A chamfered rod bushing [5] should be considered for stokes over 5 feet (1.5 meters) to prevent wear on the magnet as the piston retracts. The bushing should be made from Teflon or similar material.
- The recommended bore for the cylinder rod is 1/2 inch (13 mm). The transducer rod includes a 0.375 inch (9.53 mm) diameter end plug mounted flush. Use standard industry practices for machining and mounting of all components. Consult the cylinder manufacturer for applicable SAE or military specifications.



NOTES:
1. Dimensions and tolerances based on ANSI Y14.5-1982.
2. MTS has extracted all pertinent information from MS33649 to Generate this document.
3. PD must be square with surface B within 0.005 FIM across 2.250 dia minimum.
4. PD must be concentric with 2.250 dia within 0.030 FIM and with 0.769 dia within 0.005 FIM.
5. Surface texture ANSI B46.1-1978
6. Use o-ring MTS part number 560315 for correct sealing.
7. The thread design shall have sufficient threads to meet strength requirements of material used.
8. Finish counter-bore shall be free from longitudinal and spiral tool marks. Annular tool marks up to 32 micro-inches maximum will be permissible.

Figure 2-9
O-ring Boss Detail



NOTES:

1. If face of port is on a machined surface, dimensions 1.180 and 0.094 need not apply as long as R0.008/0.004 is maintained to avoid damage to the O-ring during installation.
2. Measure perpendicularity to A at this diameter.
3. This dimension applies when tap drill cannot pass through entire boss.
4. This dimension does not conform to SAE J1926/1.

Figure 2-10
Port Detail (SAE J1926/1)

2.5 Installing Magnets

Figure 2-11 below shows the standard magnet types and dimensions. The circular magnet with an outside diameter of 1.29 inches and 0.53 inch inside diameter (Part No. 201542) is the most common and is suitable for most applications. Larger magnets, with an outside diameter of 2.5 inches are typically only used with Temposonics transducers that exceed 180 inches in stroke length. Magnets with a 90 degree cut-out are used in applications that require intermediate supports along the transducer rod.

If upon installation, the null adjustment is inadequate, you can design a coupler with adjustments to mount the magnet to the measured member.

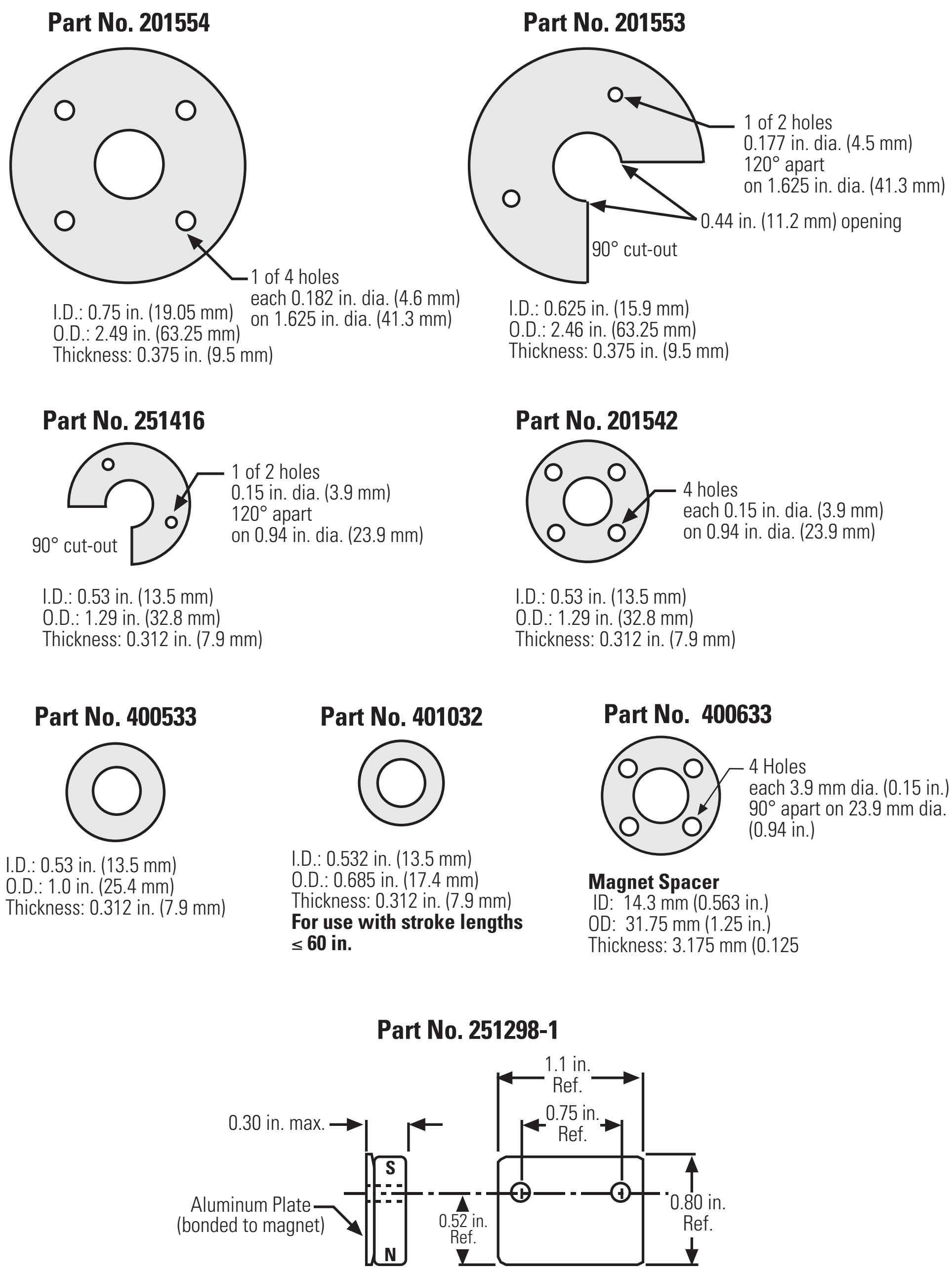


Figure 2-11
Magnet Dimensions

3. Temposonics II Wiring

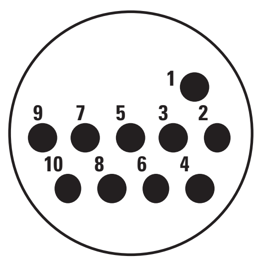
Table 3A Connections - Temposonics II Transducer with Personality Modules

Temposonics II Cable Color Code (See Note 1)

Temposonics II Configurations:
- **Neuter** - No Personality Module
- **DPM** - Digital Personality Module
- **RPM** - RS422 Personality Module
- **APM** - Analog Personality Module

Pin No.	*Wire Color (Striped leads)*	*Wire Color (Solid Leads)*	*Neuter*	*DPM*	*RPM*	*APM*
1	White/Blue Stripe	White	DC Ground	DC Ground	DC Ground	DC Ground
2	Blue/White Stripe	Brown	Frame	Frame	Frame	Frame
3	White/Orange Stripe	Gray	Not Used	(-) Gate Out	(-) Start/Stop Pulse	Displacement Return (GND)
4	Orange/White Stripe	Pink	Not Used	(+) Gate Out	(+) Start/Stop Pulse	Displacement Out
5	White/Green Stripe	Red	+ VDC	+ VDC	+ VDC	+ VDC (See Note 6)
6	Green/White Stripe	Blue	- VDC	- VDC	- VDC	- VDC
7	White/Brown Stripe	Black	Output Pulse Return	Not Used	Not Used	Not Used
8	Brown/White Stripe	Violet	Output Pulse	Not Used	Not Used	Not Used
9	White/Gray Stripe	Yellow	+ Interrogation (See Notes 2, 3)	+ Interrogation (See Notes 2, 4)	+ Interrogation (See Notes 2, 4, 5)	Not Used
10	Gray/White Stripe	Green	- Interrogation (See Notes 2, 3)	- Interrogation (See Notes 2, 4)	- Interrogation (See Notes 2, 4, 5)	Not Used

NOTES:
1. Verify if the cable has striped or solid color leads and make connections accordingly.
2. 1 to 4 microseconds maximum pulse duration.
3. **WARNING:** Under no condition should both the positive (+) and negative (-) interrogation leads be connected at the same time when using the "NEUTER" version Temposonics II transducer. The unused interrogation lead must be connected to DC ground.
4. When using a Temposonics II transducer with a Digital Personality Module (DPM) or an RS422 Personality Module (RPM), it is recommended that both the positive and negative interrogation leads are used to produce a differential interrogation signal.
5. For external interrogation mode ONLY.
6. Temposonics II w/APM requires $^{+}$/-13.5 to $^{+}$/-15 Vdc. All others require +/-12 Vdc to +/-15 Vdc.



Temposonics II 10-Pin Connector

Table 3B Connections - Original Temposonics Transducer

Original Temposonics Connector

Pin Number	*Wire Color Code*	*Signal Function*
A	Green or Gray	+ 15 Vdc
B	Black	DC Ground
C	Orange or Brown	Return Pulse (from LDT)
D	Blue	- 15 Vdc
E	White	Interrogation Pulse
F	Red	+ 12 Vdc

Table 3C Connections - Temposonics II Transducer to Analog Output Module (AOM)

Temposonics II Cable Color Code (See Note 5)				**AOM Connections:** (Stroke Lengths < 180 in.)		**AOM Connections** (Stroke Lengths > 180 in.)	
Pin No.	***Wire Color*** *(Striped leads)*	***Wire Color*** *(Solid Leads)*	***Function***	***Terminal Blocks***	***Military Style Connectors***	***Terminal Blocks***	***Military Style Connectors***
1	White/Blue Stripe	White	DC Ground	TB2-B	J2 Pin B	TB2-B	J2 Pin B
2	Blue/White Stripe	Brown	Frame (see note 1)	TB2-B	J2 Pin B	TB2-B	J2 Pin B
3	White/Orange Stripe	Gray	Not Used	Not Used	Not Used	Not Used	Not Used
4	Orange/White Stripe	Pink	Not Used	Not Used	Not Used	Not Used	Not Used
5	White/Green Stripe	Red	+Vdc	TB2-F	J2 Pin F	TB2-A	J2 Pin A
6	Green/White Stripe	Blue	-Vdc	TB2-D	J2 Pin D	TB2-D	J2 Pin D
7	White/Brown Stripe	Black	Output Pulse Return	TB2-B	J2 Pin B	TB2-B	J2 Pin B
8	Brown/White Stripe	Violet	Output Pulse	TB2-C	J2 Pin C	TB2-C	J2 Pin C
9	White/Gray Stripe	Yellow	+ Interrogation (See notes 2, 4)	TB2-E	J2 Pin E	TB2-E	J2 Pin E
10	Gray/White Stripe	Green	- Interrogation (See notes 3, 4)	TB2-E	J2 Pin B	TB2-E	J2 Pin B

NOTES:

1. Frame ground is isolated from circuit ground inside the transducer head.
2. For retrofitting AOMs or DIBs with strooke lengths greater than 12 inches (+ interrogation pulse).
3. For retrofitting AOMs or DIBs with stroke lengths of 12 inches or less (-interrogation pulse).
4. IMPORTANT: under no condition should both the positive (+) and negative (-) interrogation leads be connected at the same time. The unused interrogation lead must be connected to DC ground.
5. Verify if the cable has striped or solid color leads and make connections accordingly.

Table 3D Connections - Temposonics II to Digital Interface Box (DIB)

Temposonics II Cable Color Code (See Note 1)				**DIB Connections:**	
Pin No.	***Wire Color*** *(Striped leads)*	***Wire Color*** *(Solid Leads)*	***Function***	***J2 Pin Connections***	***Retrofit connections to Mating Connector*** *(P/N 370160, See Note 2)*
1	White/Blue Stripe	White	DC Ground	J2 Pin B	A
2	Blue/White Stripe	Brown	Frame (see note 2)	J2 Pin B	J
3	White/Orange Stripe	Gray	Not Used	Not Used	K
4	Orange/White Stripe	Pink	Not Used	Not Used	G
5	White/Green Stripe	Red	+Vdc	J2 Pin F (Pin A if stroke length is > 180 in.)	H
6	Green/White Stripe	Blue	-Vdc	J2 Pin D	B
7	White/Brown Stripe	Black	Return (Gnd.)	J2 Pin B	Not Used
8	Brown/White Stripe	Violet	Output (return pulse)	J2 Pin C	Not Used
9	White/Gray Stripe	Yellow	+ Interrogation	J2 Pin E	E
10	Gray/White Stripe	Green	- Interrogation	J2Pin B	D

NOTES:

1. Frame ground is isolated from circuit ground inside the transducer head.
2. Verify if the cable has striped or solid color leads and make connections accordingly.
3. Connections to existing mating connector when replacing a Digital Interface Box with a Temposonics II LDT with a Digital Personality Module.

4. Grounding

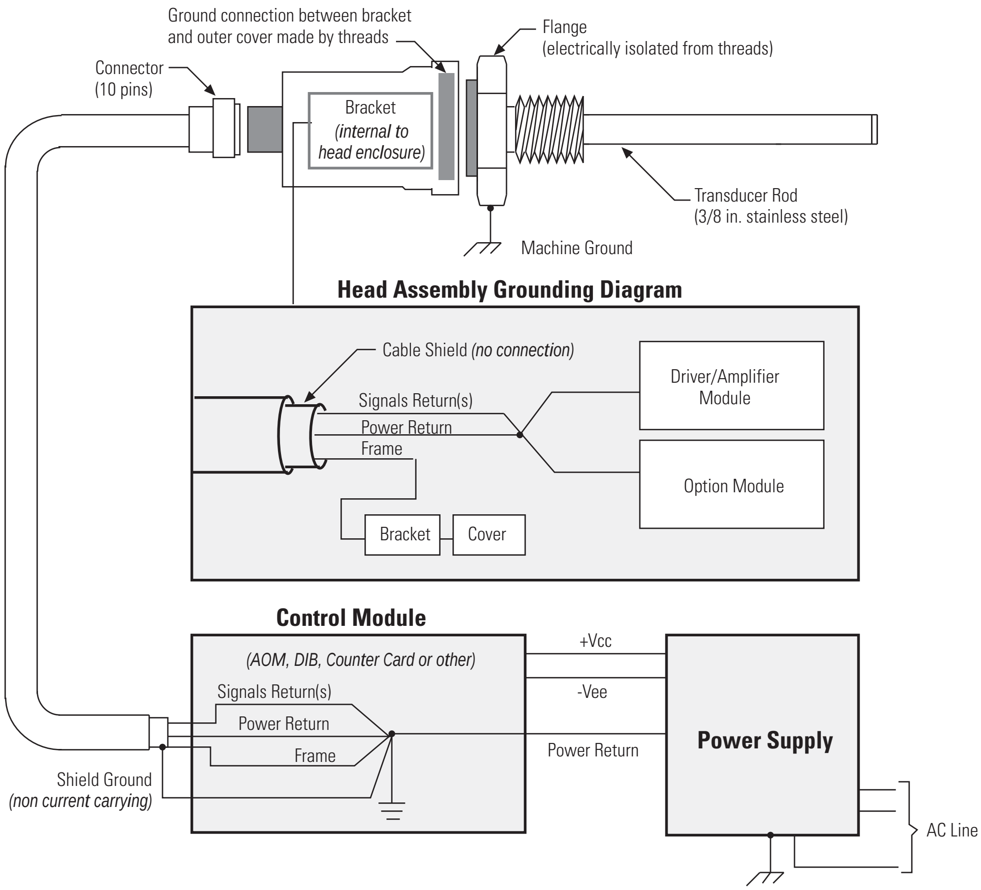


Figure 4-1
Grounding

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Part Number: 11-98 550055 Revision E

Temposonics®

Position Sensors and Systems

Temposonics® II Position Sensors

Installation & Instruction Manual for Analog Systems

11-98 550032 Revision F

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1. Introduction to the Temposonics II Linear Displacement Transducer (LDT)

The Temposonics II LDT precisely senses the position of an external magnet to measure displacement with a high degree of accuracy and resolution. Using the principle of magnetostriction (see Section 1.1, below), the Temposonics II LDT measures the time interval between the initiation of an interrogation pulse and the detection of a return pulse. A variety of interface devices use the data derived from these two pulses and generates an analog or digital output to represent position.

1.1 Theory of Operation/Magnetostriction

The interrogation pulse travels the length of the transducer by a conducting wire threaded through a hollow waveguide. The waveguide is spring loaded within the transducer rod and exhibits the physical property of magnetostriction. When the magnetic field of the interrogation pulse interacts with the stationary magnetic field of the external magnet, a torsional strain pulse or “twist” is produced in the waveguide. This strain pulse travels in both directions, away from the magnet. At the end of the rod, the strain pulse is damped within the “dead zone”. At the head of the transducer, two magnetically coupled sensing coils are attached to strain sensitive tapes. The tapes translate the strain pulse through coils to an electrical “return pulse”. The coil voltage is then amplified in the head electronics before it is sent to various measuring devices as the conditioned “return pulse”.

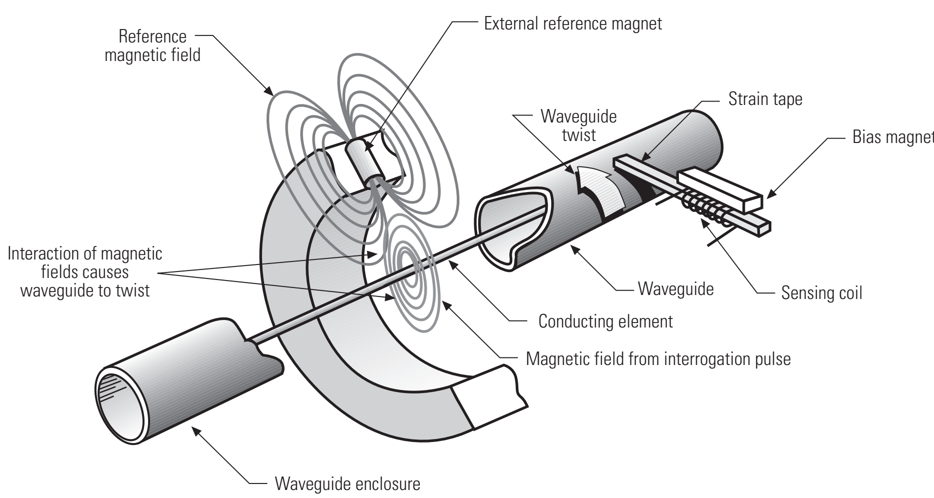


Figure 1-1
Waveguide Interaction

1.2 Temposonics II LDT Specifications for Sensors <180 Inches

Parameter	**Specifications**
Input Voltage:	± 12 to ± 15 Vdc
Current Draw:	***Transducer Only:*** ± 15 Vdc at 100 mA maximum, 25 mA minimum (current draw varies with magnet position, maximum draw occurs when magnet is at 2 in. (50.6 mm) from the flange and minimum update time is being utilized) ***Transducer with:*** • *Analog Personality Module (APM):* ± 13.5 Vdc to ±15 Vdc at 190 mA maximum, 115 mA minimum • *Analog Output Module (AOM):* + 15 Vdc at 250 mA, -15 Vdc at 65 mA
Displacement:	Up to 25 feet (7620 millimeters)
Dead Zone:	2.5 inches (63.5 millimeters) for stroke lengths up to 179.9 in.
Electronics Enclosure:	IP-67
Non-linearity:	< ± 0.05% of full scale or ± 0.002 inch (±0.05 mm), whichever is greater
Resolution:	1 ÷ [gradient x crystal freq. (mHz) x circulation]; maximum resolution: 0.006 mm or 0.00025 in.
Repeatability:	Equals resolution
Hysteresis:	0.0008 inch (0.02 mm) maximum
Update Time:	Resolution and Stroke dependent Minimum = [Stroke (specified in inches) + 3] x 9.1 µs
Operating Temperature Head Electronics: Transducer Rod:	 - 40 to 150°F (- 40 to 66°C) - 40 to 185°F (- 40 to 85°C)
Operating Pressure:	3000 psi continuous, 8000 psi static
Analog Outputs (absolute)	Standard 0 to10 Vdc (other voltage outputs are available) Optional: 4-20 mA (AOM)

Specifications are subject to change without notice. Consult MTS for verification of specifications critical to your application.

1.3 Temposonics II LDT Specifications for Sensors ≥180 Inches

Below is a list of specifications that pertain to Temposonics II transducers with active stroke lengths of 180 inches (5083 mm) to 300 inches (7620 mm). The below specifications apply only to sensors 180 to 300 inches in length. Specifications not listed below may be found in section 1.2, above.

Parameter	**Specifications**
Input Voltage:	• Maximum: ± 15 Vdc, ± 5% at 100 mA • Minimum: ± 15 Vdc at 25 mA (current draw varies with magnet position, maximum draw occurs when magnet is 2 inches (50.8 mm) from the flange and minimum update time is being used)
Dead Zone:	3 in. (76.2 mm)
Cable Length:	• Maximum cable length for neuter version transducer (i.e., Temposonics II without an integrated Personality Module) which requires the use of external interface electronics (Analog Output Module, Digital Interface Box or other signal conditioners) is 250 ft. • APM: 150 ft. AOM: 250 ft.
Magnet Requirement:	Part Numbers: 201554, 201553, 251416, 201542

Specifications are subject to change without notice. Consult MTS for verification of specifications critical to your application.

2. Temposonics II LDT Installation

Before beginning installation, be sure you know the following dimensions (as illustrated in Figures 2-1 to 2-3a-c.):

- Null Space
- Stroke
- Dead Zone

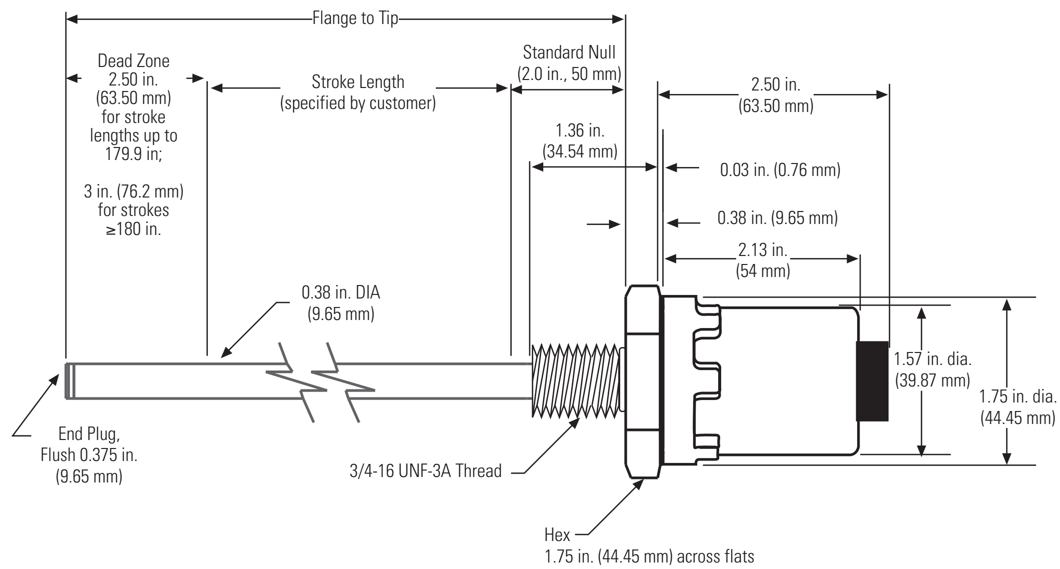


Figure 2-1
Temposonics II Dimensions

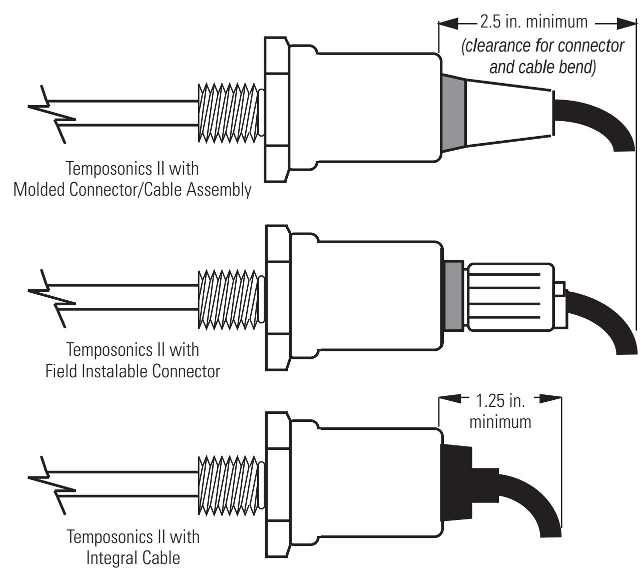


Figure 2-2
Temposonics II Connector/Cable Clearance Requirements

1. Use the 3/4 inch (19 mm), 16 UNF thread of the transducer to mount it at the selected location. Leave room to access the hex head. If a pressure or moisture seal is required, install an O-ring (type MS 28778-8 is recommended) in the special groove. Use the hex head to tighten the transducer assembly.

2. Install the permanent magnet over the LDT rod. Mount the permanent magnet to the movable device whose displacement will be measured. To minimize the effect of magnetic materials (i.e. iron, steel, etc.) on the magnetic field of the permanent magnet, ensure the minimum spacing requirements are met as shown in Figures 2-3a-c. (Any non-magnetic materials can be in direct contact with the permanent magnet without affecting performance.)

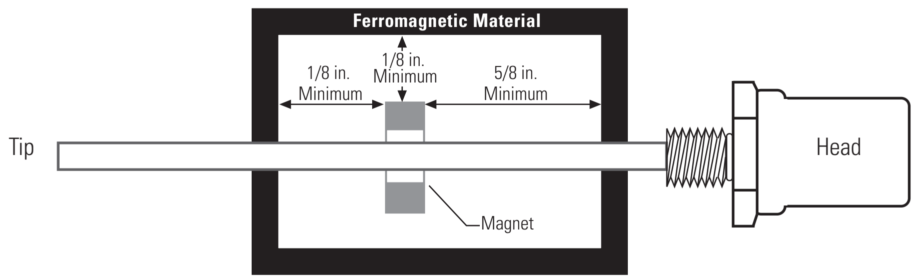


Figure 2-3a
Minimum Magnet Clearance Using Magnetic Supports

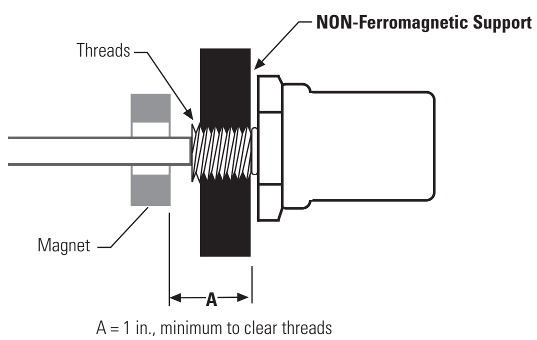


Figure 2-3b
Minimum Null Space Using Non-Magnetic Support

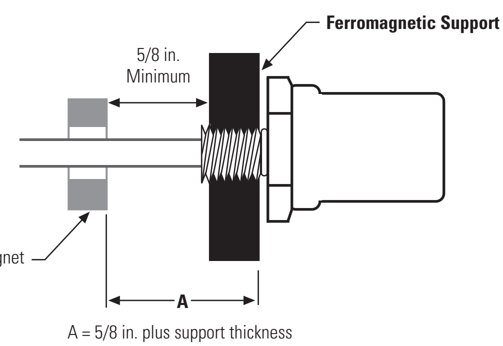


Figure 2-3c
Minimum Null Space Using Magnetic Support

NOTES:
1. The magnet must not contact ferromagnetic materials (such as iron or steel). Clearances are required between the surface of the magnet and ferromagnetic material, as shown. Non-ferrous material (such as copper, brass, or 300 series stainless steel) may contact the magnet without affecting transducer performance.
2. Standard Null Space is 2 inches. There is no maximum limit for Null Space. Less then 2 inches can be specified if magnet clearances meet requirements illustrated above.

> **NOTE:**
>
> *Clearance between the magnet and the transducer rod is not critical. However, contact between the components will cause wear over time. The installation of supports or readjustment of the supports is recommended if the magnet contacts the transducer rod.*

3. Move the permanent magnet full-scale to check that it moves freely. If not (if the magnet rubs on the transducer) you can correct this by mounting a support bracket to the end of the transducer. Long transducers may need additional supports to be attached to the transducer rod. Transducer supports are described later in this section.

2.1 Types of Transducer Supports

Long transducers (48 inches or longer) may require supports to maintain proper alignment between the transducer rod and the permanent magnet. When transducer rod supports are used, special, open-ended permanent magnets are required.

Transducer supports attached to the active stroke length must be made of a non-ferrous material, thin enough to permit the permanent magnet to pass without obstruction. Because the permanent magnet does not enter the dead zone, supports connected within the dead zone may be made of any material. The main types of supports are loop, channel, and guide pipe supports.

2.1.1 Loop Supports

Loop supports are fabricated from non-ferrous materials, thin enough to permit free movement of the magnet. Loop supports are recommended for straight transducers and may be spaced apart approximately every three feet. They may be used alone or with channel supports. Figure 2-4 illustrates the fabrication of a loop support.

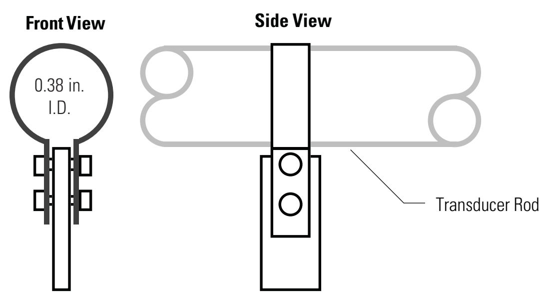


Figure 2-4
Loop Support

> **NOTE:**
>
> *When open magnets are used, ensure the transducer rod remains within the inside diameter of the magnet throughout the length of the stroke. If the transducer rod is allowed to enter the cut out area of an open magnet, the transducer signal could attenuate or be lost. See Figure 2-7.*

2.1.2 Channel Supports

Channel supports, being typically straight, are normally used with rigid transducers. A channel support consists of a straight channel with loop supports mounted at intervals. The loop supports are required to keep the transducer within the channel. Figure 2-5 shows a channel support. Channel supports are available from various manufacturers or may be fabricated.

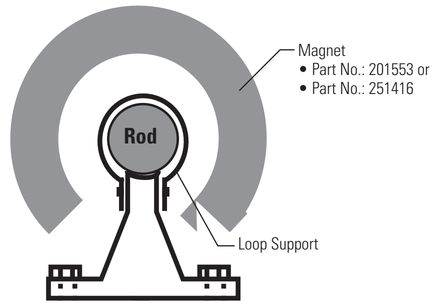


Figure 2-5
Channel Support

2.1.3 Guide Pipe Supports

Guide pipe supports are normally used for flexible transducers. A guide pipe support is constructed of non-ferrous material, straight or bent to the desired shape. As shown in Figure 2-6, both inside and outside dimensions of the pipe are critical:

- Because the transducer rod is installed inside the pipe, the inside diameter of the pipe must be large enough to clear the rod.

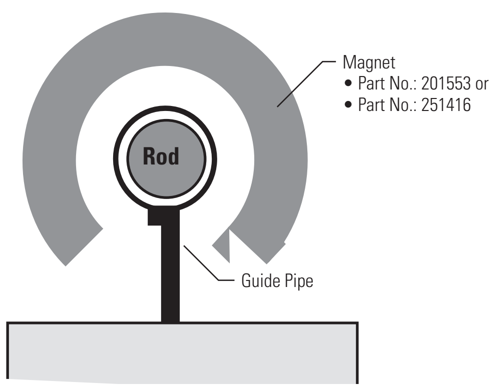


Figure. 2-6
Guide Pipe Support

- The outside diameter of the pipe must be small enough to clear the magnet.

Refer to pipe manufacturers' specifications and dimensions (schedule 10, 40, etc.) to select the appropriate size pipe. Guide pipe is typically supported at each end of the pipe.

2.2 Open Magnets

When using an open magnet, make sure the rod is positioned at all times within the “active” zone of the magnet. The transducer cannot operate properly unless the entire stroke of the transducer rod is located within this zone. The active zone, as shown in Figure 2-7, lies within the inside diameter of the magnet.

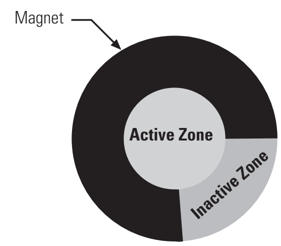


Figure 2-7
Active Zone for Open Magnets

2.3 Spring Loading or Tensioning

The transducer rod can be spring loaded or tensioned using a stationary weight. Attach a spring mechanism or weight to the dead zone of the transducer rod with a clamping device which will not deform the transducer rod. The maximum weight or spring tension is 5 to 7 lbs.

2.4 Cylinder Installation

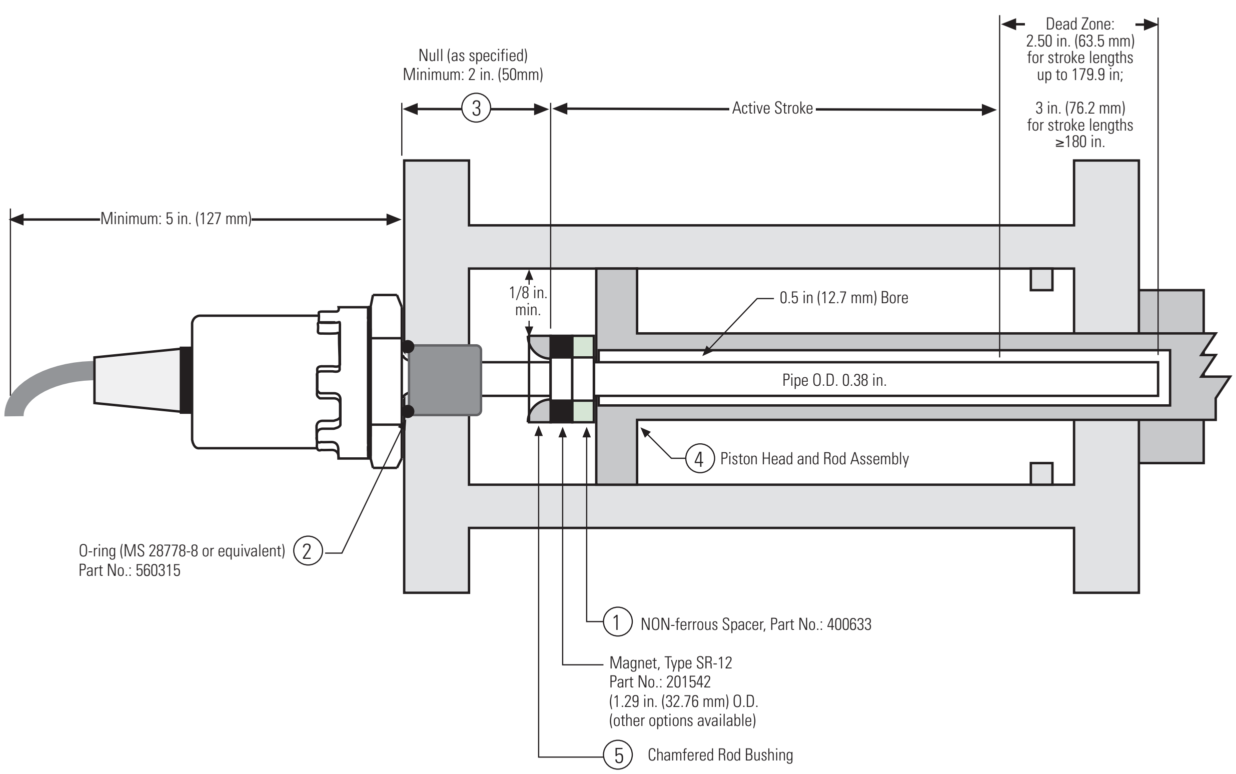
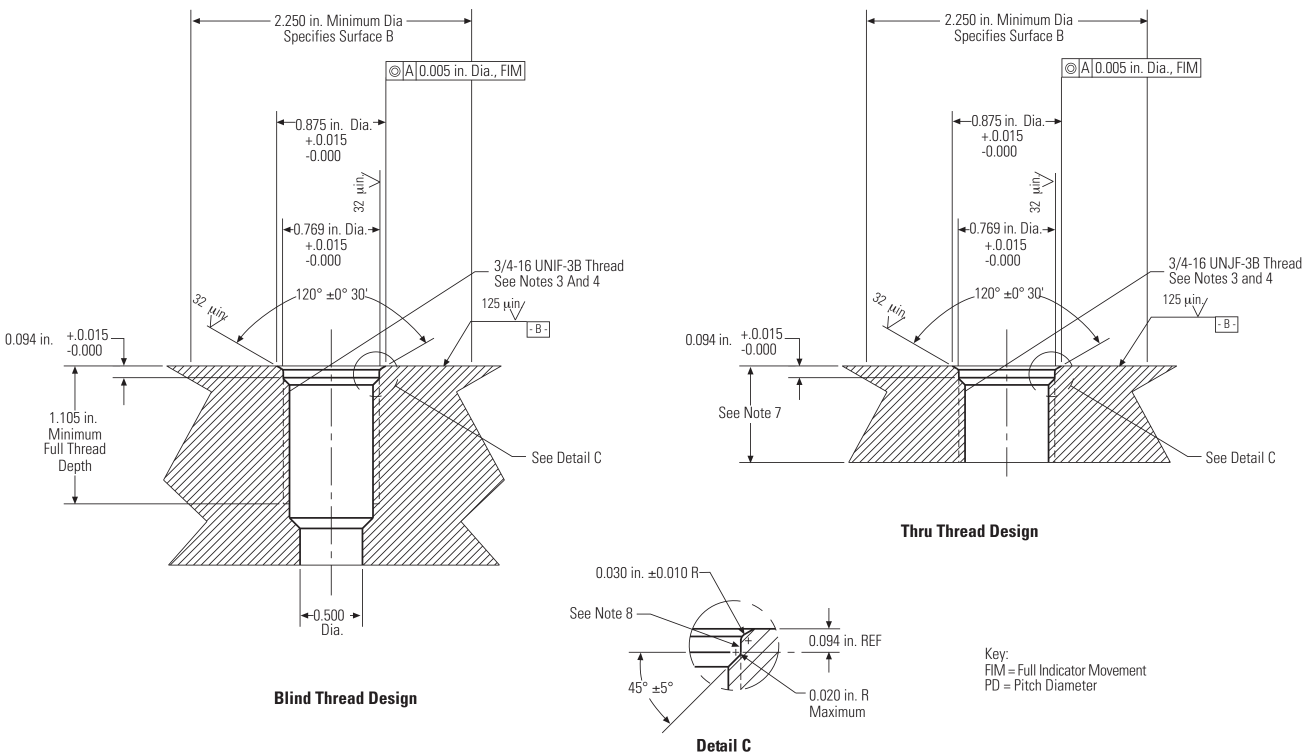


Figure 2-8
Typical Cylinder Installation

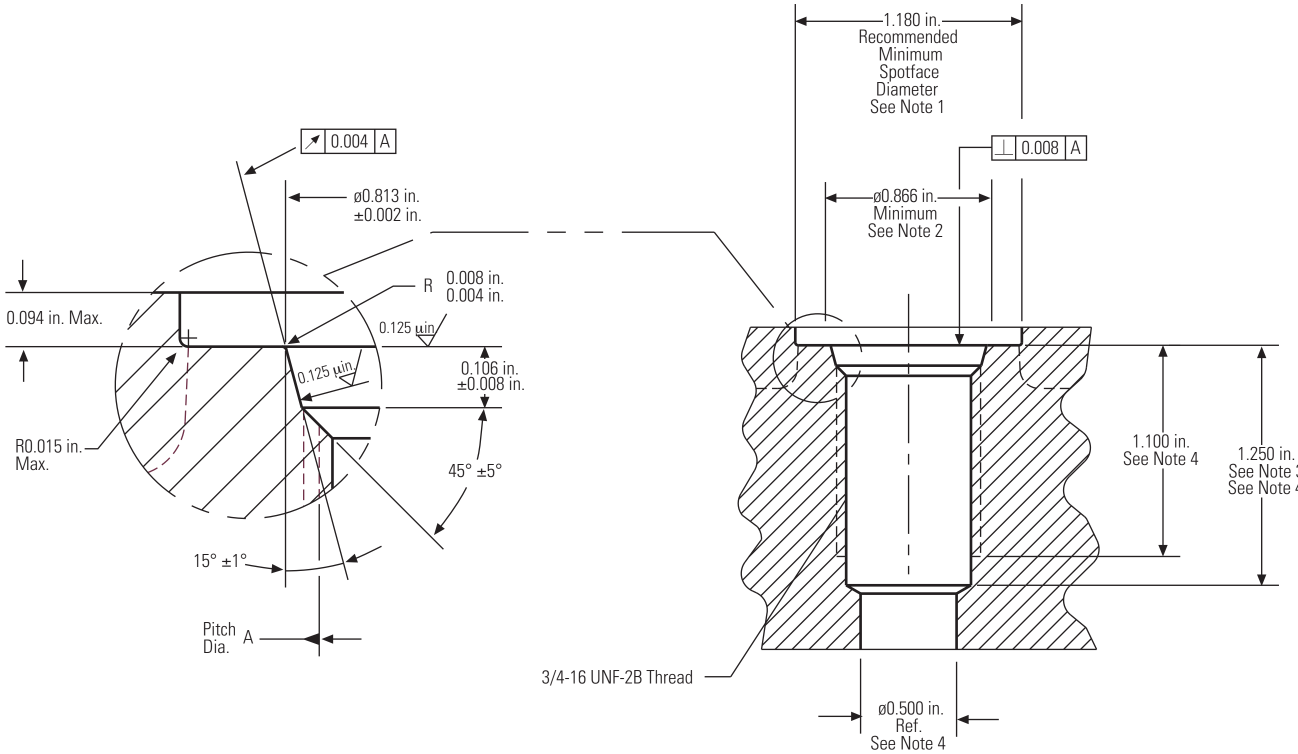
Figure 2-8 shows a typical cylinder installation. Review the following before attempting this type of installation.

- Use a non-ferrous (plastic, brass, Teflon®, etc.) spacer [1] to provide 1/8 inch (32 mm) minimum space between the magnet and the piston.
- An O-ring groove [2] is provided at the base of the transducer hex head for pressure sealing. MTS uses mil-standard MS33514 for the O-ring groove. Refer to mil-standard MS33649 or SAE J514 for machining of mating surfaces.
- The null space [3] is specified according to the installation design and cylinder dimensions. The analog output module provides a null adjustment. Make sure that the magnet can be mounted at the proper null position.
- The piston head [4] shown in Figure 2-8 is typical. For some installations, depending on the clearances, it may be desired to countersink the magnet.
- A chamfered rod bushing [5] should be considered for stokes over 5 feet (1.5 meters) to prevent wear on the magnet as the piston retracts. The bushing should be made from Teflon or similar material.
- The recommended bore for the cylinder rod is 1/2 inch (13 mm). The transducer rod includes a 0.375 inch (9.53 mm) diameter end plug mounted flush. Use standard industry practices for machining and mounting of all components. Consult the cylinder manufacturer for applicable SAE or military specifications.



NOTES:
1. Dimensions and tolerances based on ANSI Y14.5-1982.
2. MTS has extracted all pertinent information from MS33649 to Generate this document.
3. PD must be square with surface B within 0.005 FIM across 2.250 dia minimum.
4. PD must be concentric with 2.250 dia within 0.030 FIM and with 0.769 dia within 0.005 FIM.
5. Surface texture ANSI B46.1-1978
6. Use o-ring MTS part number 560315 for correct sealing.
7. The thread design shall have sufficient threads to meet strength requirements of material used.
8. Finish counter-bore shall be free from longitudinal and spiral tool marks. Annular tool marks up to 32 micro-inches maximum will be permissible.

Figure 2-9
O-ring Boss Detail



NOTES:

1. If face of port is on a machined surface, dimensions 1.180 and 0.094 need not apply as long as R0.008/0.004 is maintained to avoid damage to the O-ring during installation.
2. Measure perpendicularity to A at this diameter.
3. This dimension applies when tap drill cannot pass through entire boss.
4. This dimension does not conform to SAE J1926/1.

Figure 2-10
Port Detail (SAE J1926/1)

2.5 Installing Magnets

Figure 2-11 below shows the standard magnet types and dimensions. The circular magnet with an outside diameter of 1.29 inches and 0.53 inch inside diameter (Part No. 201542) is the most common and is suitable for most applications. Larger magnets, with an outside diameter of 2.5 inches are typically only used with Temposonics transducers that exceed 180 inches in stroke length. Magnets with a 90 degree cut-out are used in applications that require intermediate supports along the transducer rod.

If upon installation, the null adjustment is inadequate, you can design a coupler with adjustments to mount the magnet to the measured member.

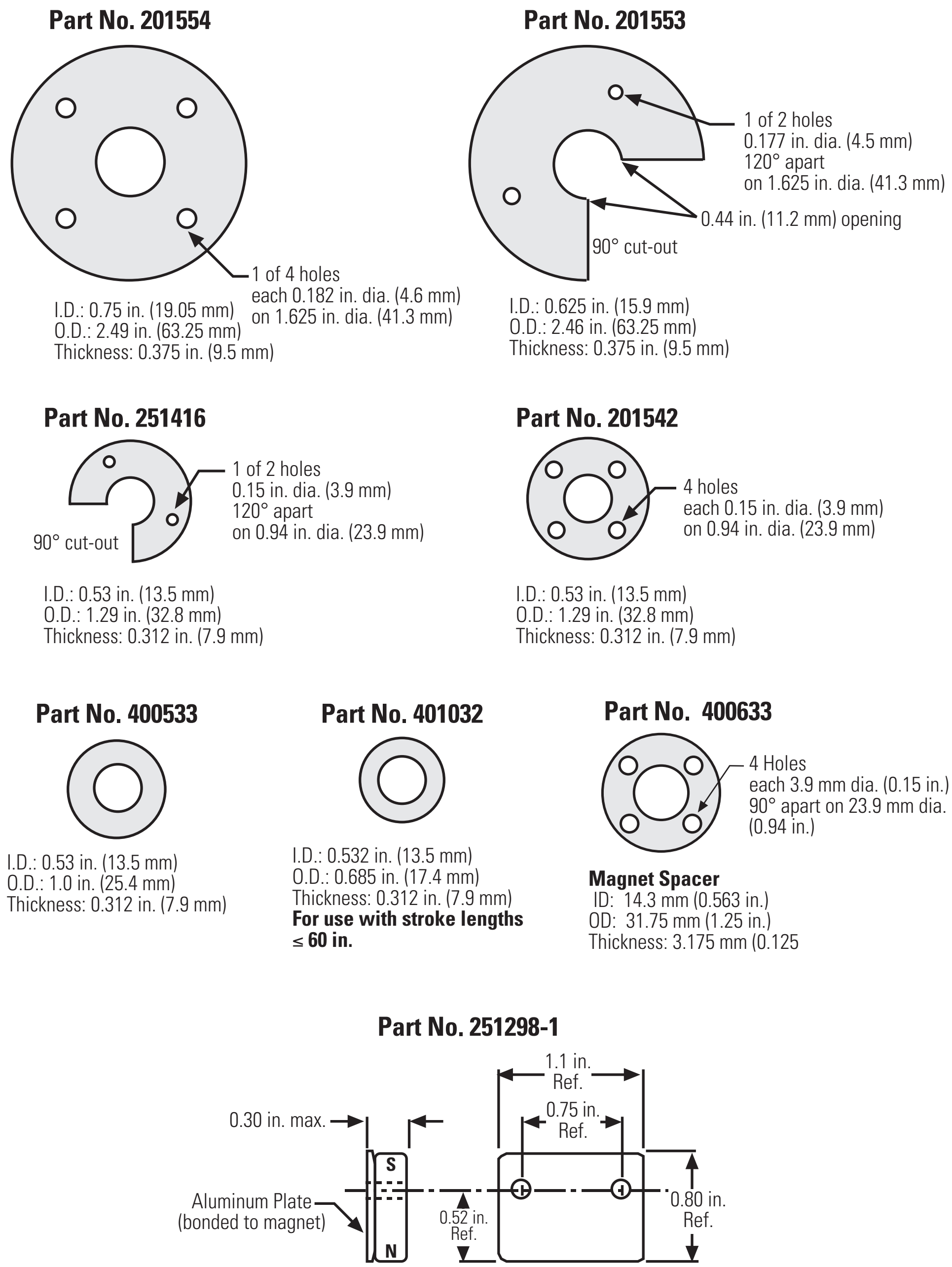


Figure 2-11
Magnet Dimensions

3. Temposonics II Wiring

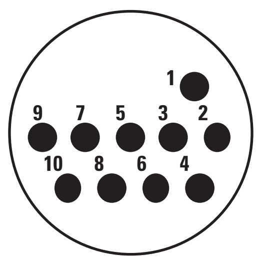
Table 3A

Temposonics II Connections (Neuter Version and with APM)

	Temposonics II Integrated or Extension Cable (see Note 1)		**Temposonics II Configurations: • Neuter - No Personality Module • APM - Analog Personality Module**	
Pin No.	***Wire Color Code***	***Wire Color Code***	***Neuter***	***APM Option***
1	White/Blue Stripe	White	DC Ground	DC Ground
2	Blue/White Stripe	Brown	Frame	Frame
3	White/Orange Stripe	Gray	Not Used	Displacement Return
4	Orange/White Stripe	Pink	Not Used	Displacement Out
5	White/Green Stripe	Red	+Vdc	+Vdc
6	Green/White Stripe	Blue	-Vdc	-Vdc
7	White/Brown Stripe	Black	Output Pulse Return	Not Used
8	Brown/White Stripe	Violet	Output Pulse	Not Used
9	White/Gray Stripe	Yellow	(+) Interrogation (Notes 2, 3)	Not Used
10	Gray/White Stripe	Green	(-) Interrogation (Notes 2, 3)	Not Used

NOTES:

1. Verify if the cable has striped or solid color leads and make connections accordingly.
2. 1 to 4 microseconds maximum pulse duration.
3. **WARNING:** Under no condition should both the positive (+) and negative (-) interrogation leads be connected at the same time when using the "NEUTER" version Temposonics II transducer. The unused interrogation lead must be connected to DC ground.
4. Temposonics II w/APM requires $^{+}$/-13.5 to $^{+}$/-15 Vdc. All others require +/-12 Vdc to +/-15 Vdc.



Temposonics II 10-Pin Connector
(connections styles RB or RC)

Table 3B

Connections - Original Temposonics Transducer

Original Temposonics Connector Pin Number	***Wire Color Code***	***Signal Function***
A	Green or Gray	+ 15 Vdc
B	Black	DC Ground
C	Orange or Brown	Return Pulse (from LDT)
D	Blue	- 15 Vdc
E	White	Interrogation Pulse
F	Red	+ 12 Vdc

4. Troubleshooting the Linear Displacement Transducer

> **NOTE:**
>
> *The following checklist is for general diagnostic purposes. Purchase of replacement components should not be based solely on this checklist. Consult MTS Sensors Division for recommendations and factory service before ordering replacement components.*

Use the below checklist when operational problems are encountered. The possible causes of faulty output are listed below in order of probability of occurrence, and should be checked in order.

1. Improper power supply/power connection
2. Mismatched system components*
3. Ground loops/improper grounding*
4. Improper wiring
5. Incorrect receiver device or software*
6. Improper magnet mounting
7. EMI noise, affecting transducer or transducer cable
8. Circuit fault within transducer

** Will cause erratic or unstable output*

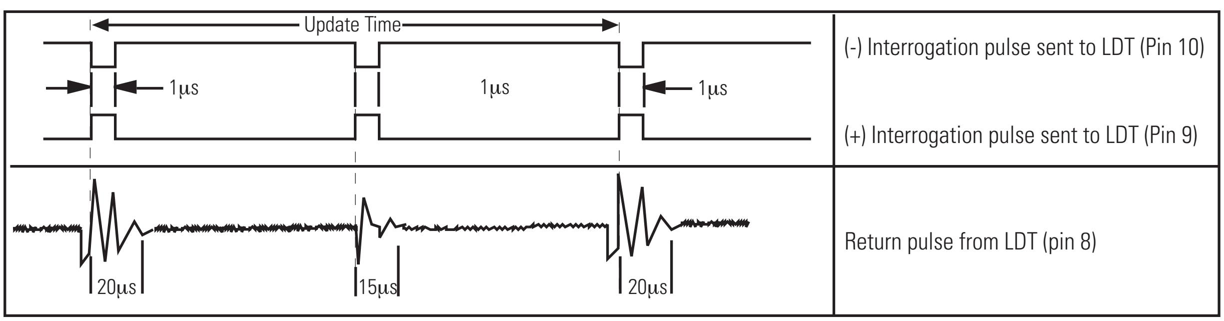


Figure 4-1
Temposonics II Transducer Signals

5. Grounding

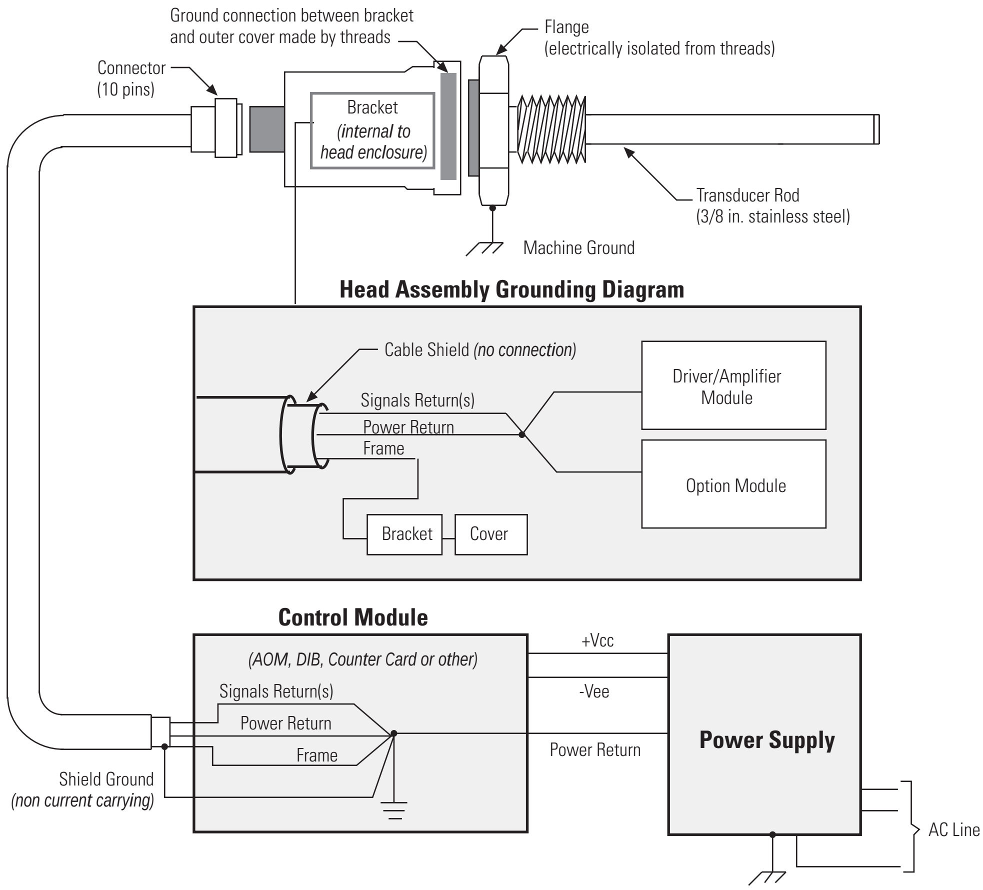


Figure 5-1
Grounding

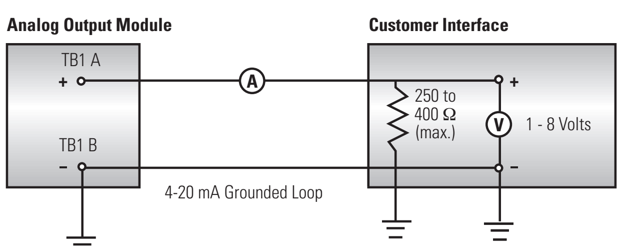


Figure 5-2
4-20mA Grounded Loop

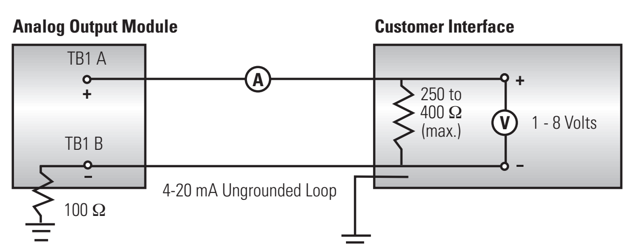


Figure 5-3
4-20mA Ungrounded Loop

NOTES FOR FIGURES 5-2 & 5-3:

1. Selecting the grounding scheme is dependent upon the controller interface.
2. The current loop path must be completed for the system to operate.
3. The ungrounded loop is not truly isolated from ground. Isolators are required if this configuration is needed by the controller interface.

6. Introduction to Analog Systems

Temposonics II Analog Systems include a Linear Displacement Transducer (LDT), a magnet, and an Analog Personality Module (APM), Analog Output Module (AOM), or an Analog Output Card. See Figures 6-1, 6-2 and 6-3. The APM, AOM and Analog Output Card generate the interrogation pulse, sense the return pulse, and develop the analog output displacement signal (voltage or current).

The Analog Personality Module (Figure 6-1) is installed in the electronics enclosure of the Temposonics II transducer. The Analog Output Module and Analog Output Card are both separate interface devices.

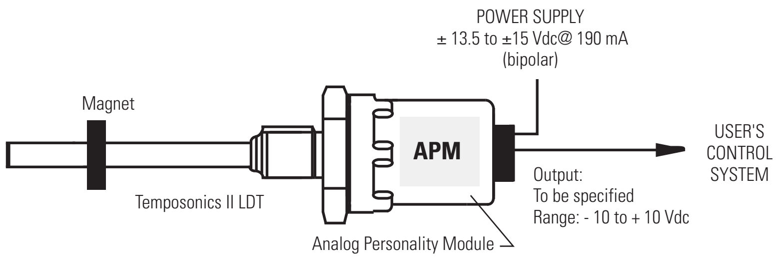


Figure 6-1
Analog System Configuration with Analog Personality Module

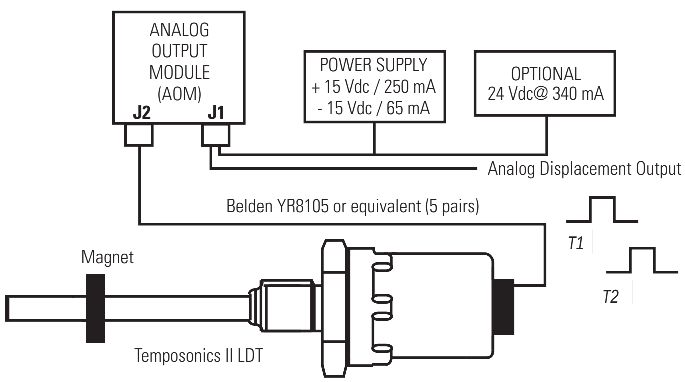


Figure 6-2
Analog System Configuration
with Analog Output Module (AOM)

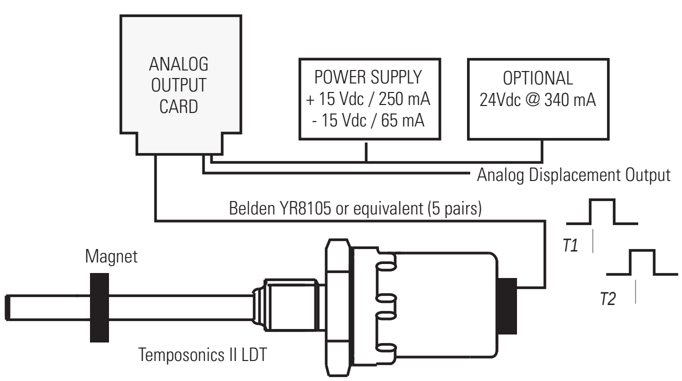


Figure 6-3
Analog System Configuration
with Analog Output Card

6.1 Specifications of Analog System Components

6.1a Analog Personality Module (APM)

Parameter	***Specification***
Power Requirements:	± 13.5 Vdc to ± 15 Vdc at 190 mA maximum, 115 mA minimum
Output Impedance:	10 KΩ minimum load for voltage output
Output:	Specified by user; Range: - 10 Vdc to + 10 Vdc, forward or reverse acting
Temperature Requirements:	
Storage:	- 40 to 150°F (- 40 to 70°C)
Operating:	- 32 to 150°F (-30 to 70°C)
Coefficient:	10 ppm/°F (18 ppm °C)
Maximum Cable Length:	150 ft.
Standard Features:	Field programmable

Specifications are subject to change without notice. Consult MTS for verification of specifications critical to your application.

6.1b Analog Output Module (AOM) and Analog Output Card

Parameter	***Specification***
Power Requirements:	
Standard:	+ 15 Vdc (±2%) at 250 mA, < 1% ripple - 15 Vdc (±2%) at 65 mA, < 1% ripple
Optional:	+ 24 Vdc (±2%) at 340 mA, < 1% ripple
Output Impedance:	5 KΩ minimum load for voltage output, 400Ω maximum for 4-20 mA output
Velocity Output:	0 to ± 10 Vdc at 1 to 400 in. per second Positive voltage output as magnet travels away from the transducer's head assembly, negative voltage output as the magnet travels toward the transducer's head assembly.
Temperature Requirements:	
Storage:	- 40 to 180°F (- 40 to 82°C)
Operating:	- 40 to 180°F (- 40 to 82°C)
Coefficient:	20 ppm/°F (36 ppm/°C)
Standard Features:	Non-volatile memory permanently stores set-up information. Surface mounted components reduce moment of inertia and enhance shock and vibration resistance of the module.

Specifications are subject to change without notice. Consult MTS for verification of specifications critical to your application.

7. Analog Personality Module

The Analog Personality Module (APM) is mounted inside the electronics housing of the Temposonics II linear displacement transducer and produces a direct analog output. No additional interfacing electronics are required. The APM processes digital data into an analog output via a digital to analog converter (DAC). MTS uses a 16-bit DAC to provide the best available resolution performance.

Typically the APM will be ordered with the Temposonics II transducer. The APM is installed, and the set points and output voltages are pre-set at the factory.

In the example below (Figure 7-1) we have a 60 inch stroke, note the indicated active stroke range. Set points cannot be set within the null or dead space area, they can only be set within the active stroke area. The 13 inch stroke selected in the example is defined by Set Point 1 (set at 4.000 volts) and Set Point 2 (set at 7.538 volts). Set Point voltage values can range from -10 to +10 Vdc.

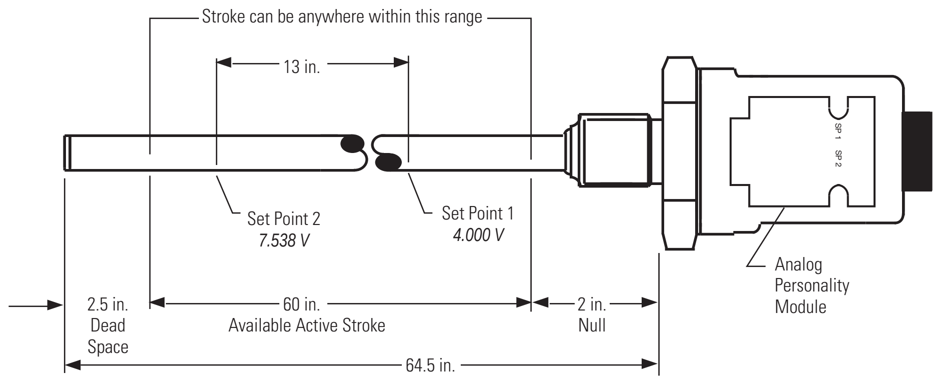


Figure 7-1
Voltage & Displacement - 100% Scalable.

7.1 Performance Modes

Update time (or response time) for analog systems is based upon the active stroke of the transducer and the resolution desired. To get the best mix of update time and resolution for your particular application, three modes are available with the APM. These modes are as follows:

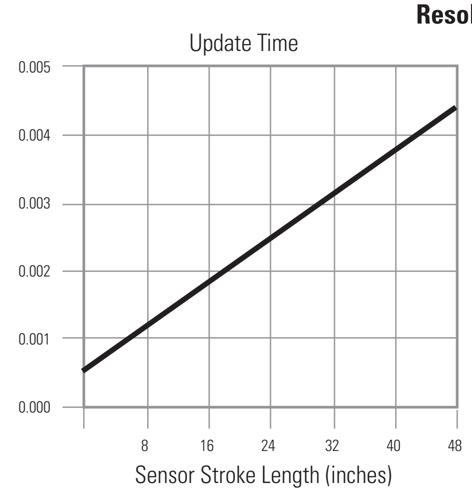
Resolution-Preferred Mode - In this mode the APM generates a high resolution output while sacrificing update time. The Resolution Preferred Mode is limited to stroke lengths up to 48 inches and will provide an output resolution of approximately 0.001 inches. In applications exceeding 48 inches, the APM must be set for Balanced Mode or Update Preferred Mode. In the programming procedure, the Resolution Preferred Mode is indicated by an output of 0 volts.

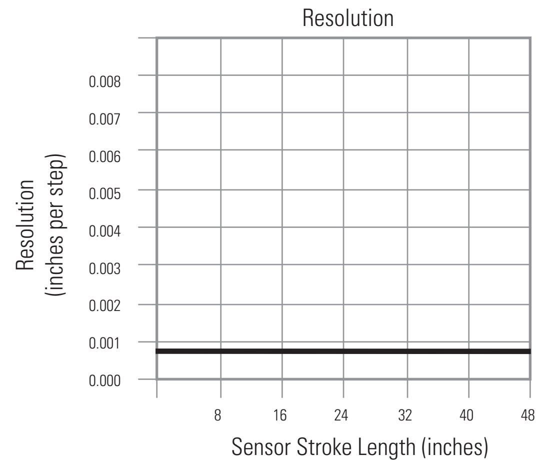
Balanced Mode - In this mode the APM offers a "balance" between update time and resolution. For stroke lengths up to 250 inches, the output resolution will be approximately 0.003 inches. In the programming procedure, this mode is indicated by an output of +8.4 volts.

Update Preferred Mode - In this mode the APM produces the fastest possible update time while sacrificing resolution. For stroke lengths up to 300 inches, the output resolution will be approximately 0.007 inches. In the programming procedure, this mode is indicated by an output of -8.4 volts.

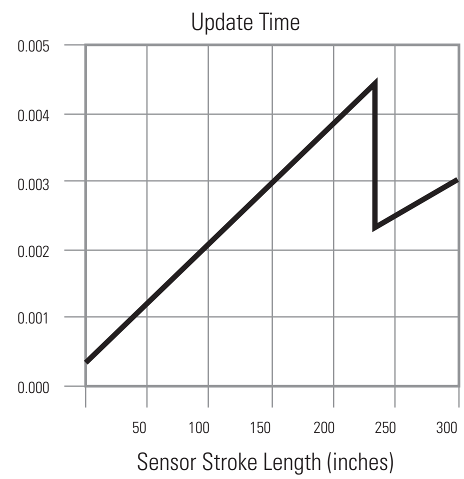
The mode desired is selected at the time of order and factory pre-set. The following charts identify the update time and resolution for each mode.

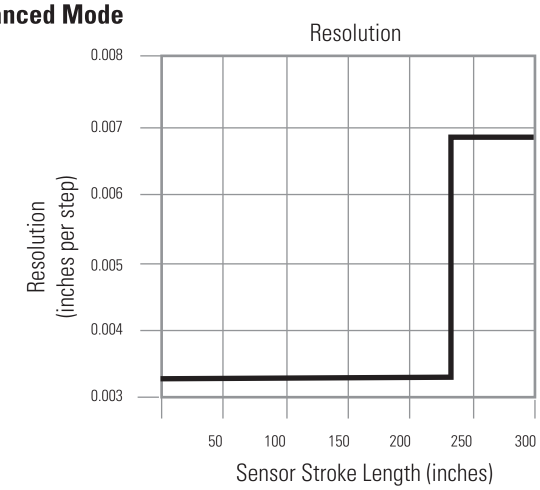
Resolution Preferred Mode



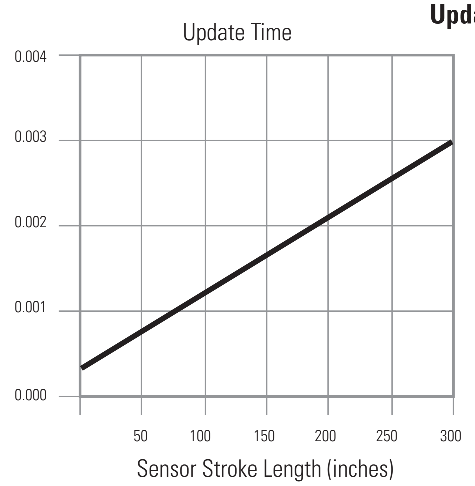


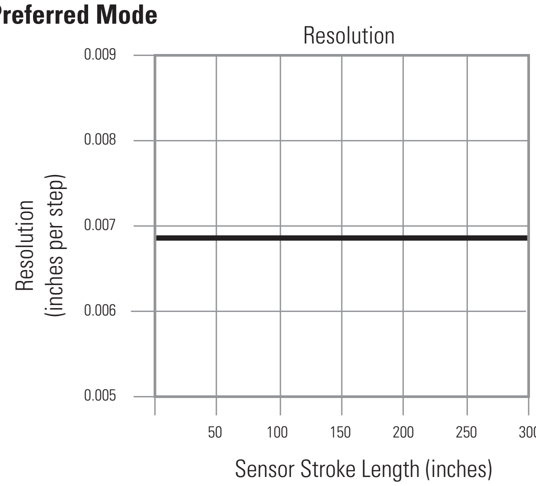
Balanced Mode





Update Preferred Mode





! CAUTION !

If the APM is being programmed for the first time, the analog output at power-up will be near zero volts. The programming steps are the same in this case, but the analog output will return to zero volts until valid information is stored for both Set Point 1 and Set Point 2. When both Set Points have been programmed, the transducer will enter normal operating mode and produce an analog output scaled according to the information permanently stored in the APM's memory.

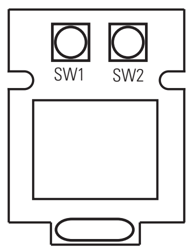


Figure 7-2
APM, Top View

! CAUTION !

IMPORTANT: Before beginning the programming procedures, supply power to the APM for a full 5 minutes. This will allow all components to stabilize and ensure set point accuracy.

The output range of the APM is determined by choosing two endpoints within the active stroke length of the transducer and using the two push-buttons to assign a voltage to each point. The two endpoints are called Set Point 1 (SW1) and Set Point 2 (SW2). Any voltage from -10 volts to +10 volts may be assigned to either point; the APM will automatically scale the output to the specified range. Set Point 1 must be the set point closest to the head electronics.

In addition, the APM can be programmed for one of three performance modes, as described earlier. During the programming procedure, each mode is represented by a particular output voltage. They are as follows:

Resolution-Preferred Mode - In the programming procedure, the Resolution Preferred Mode is indicated by an output of 0 volts.

Balanced Mode - In the programming procedure, this mode is indicated by an output of +8.4 volts.

Update Preferred Mode - In the programming procedure, this mode is indicated by an output of -8.4 volts.

The number of recirculations shown will also indicate which mode the APM is programmed, see Mode Table below.

Mode Table

Mode Select Voltages*	Recirculations
Resolution Mode = 0.0 V	8 recirculations
Balance Mode = + 8.4 V	2 recirculations
Update Mode = - 8.4 V	1 recirculation

** Voltages are approximate values.*

When programming the APM, use the table below as a reference.

APM Programming Reference Guide

Press	Approx. Output voltage	Function	Reference
SW1 (for 3 seconds)	+4.2 Vdc	Start program mode	Step 1
SW2	see mode table	Select mode	Step 2
SW1	-4.2 Vdc	Locks mode in	Step 3
SW1 (setpoint 1) or SW2 (setpoint 2)	-2.1 Vdc +2.1 Vdc	Select setpoint 1 to program Select setpoint 2 to program	Step 4 Step 10
SW1 or SW2 at setpoint 1 or 2	Desired output voltage voltage needed at setpoint 1	Select desired output	Step 5 or 11
SW1 and SW2	Setpoint voltage	Lock in program	Step 6 or 12

NOTES:

1. Always program setpoint 1 first, lock in program, then complete the steps to program setpoint 2.
2. When adjusting the output voltage (step 4) make sure the magnet is in the position of the setpoint.
3. Setpoint 1 will always be the setpoint closest to the transducer head.
4. If a mistake is made during programming, turn off power, wait a few seconds, turn power on and start over.

It is necessary to monitor the analog output with a digital voltmeter while performing the following steps.

1. Move the permanent magnet to the desired position for Set Point 1. Press the SW1 push-button until the APM enters the programming mode (3 seconds) and acknowledges by producing an output voltage of about +5 volts. Release the SW2 button.

2. Press and release the SW2 button to enter the performance-mode setup mode. The APM will acknowledge by producing an output voltage which corresponds to the currently stored performance mode (see below). If the APM has never been programmed, the default mode will be resolution-preferred (that is, the output voltage will be 0 volts).

   - Resolution Preferred Mode = 0 volts
   - Balanced Mode = +8.4 volts
   - Update Preferred Mode = -8.4 volts

3. At this point, repeated presses of the SW2 button will cause the APM to cycle through the three performance modes. Continue to press and release the SW2 button until the voltage output indicates the voltage associated with the correct mode for your application. Once the correct voltage is displayed, press and release the SW1 button to accept the mode setting. The APM acknowledges by producing an output voltage of approximately -4.2 volts.

4. Press and release the SW1 button to enter the Set Point 1 setup mode. The APM will acknowledge by producing an output voltage of about -2.1 volts.

5. At this point, you can use the SW1 and SW2 buttons to choose the voltage to assign to Set Point 1. Pressing and holding the SW1 button causes the output voltage to move in the positive direction; pressing and holding the SW2 button causes the output voltage to move in the negative direction. If either button is held for more than five seconds, the output voltage will begin to change more quickly. Release the button when the desired output voltage is displayed on the digital volt meter. (For testing purposes, it is not necessary to perform this step. It can be skipped entirely since it only assigns the final voltage to the Set Point.)

6. To complete the setup for Set Point 1, press and release both buttons simultaneously. Move magnet while looking at the output voltage. If output voltage changes, program has been locked in successfully. If output voltage does not change, put magnet back to the setpoint position and press both buttons simultaneously. If the transducer has been previously programmed, it will resume operation with the new voltage assigned to SW1. If it has not been previously programmed, it will return to the same voltage it had prior to entering the programming mode (near 0 volts).

7. Move the permanent magnet to the desired position for Set Point 2. Press the SW1 push-button until the APM enters the programming mode (3 seconds) and acknowledges by producing an output voltage of approximately +4.2 volts. Release the SW1 button.

8. Press and release the SW2 button to enter the performance-mode setup mode. The APM will acknowledge by producing an output voltage which corresponds to the currently stored performance mode. If the APM has never been programmed, the default mode will be resolution-preferred (that is, the output voltage will be 0 volts).

9. At this point, repeated presses of the SW2 button will cause the APM to cycle through the three performance modes. Continue to press and release the SW2 button until the voltage output indicates the voltage associated with the correct mode for your application. Once the correct voltage is displayed, press and release the SW1 button to accept the mode setting. The APM acknowledges by producing an output voltage of approximately -4.2 volts. (Note that the mode chosen in this step should be the same as the one chosen in step 3. If a different mode is chosen, it will overwrite the one chosen previously.)

10. Press and release the SW2 button to enter the Set Point 2 setup mode. The APM will acknowledge by producing an output voltage of +2.1 volts.

11. At this point, you can use the SW1 and SW2 buttons to choose the voltage to assign to Set Point 2. Pressing and holding the SW1 button causes the output voltage to move in the positive direction; pressing and holding the SW2 button causes the output voltage to move in the negative direction. If either button is held for more than five seconds, the output voltage will begin to change more quickly. Release the button when the desired output voltage is displayed on the digital volt meter. (For testing purposes, this step may be skipped completely.)

12. To complete the setup for Set Point 2, press and release both buttons simultaneously. Move magnet while looking at the output voltage. If output voltage changes, program has been locked in successfully. If output voltage does not change, put magnet back to the setpoint position and press both buttons simultaneously. If the transducer was previously programmed, it will resume operation with the new voltage assigned to Set Point 2.

8. Installing the Analog Output Module (AOM)

Dimensions of the AOM are shown below in Figure 8-1. The mounting hole dimensions shown are also stamped on the back of the module. Mount the AOM as shown, using two socket head cap-screws.

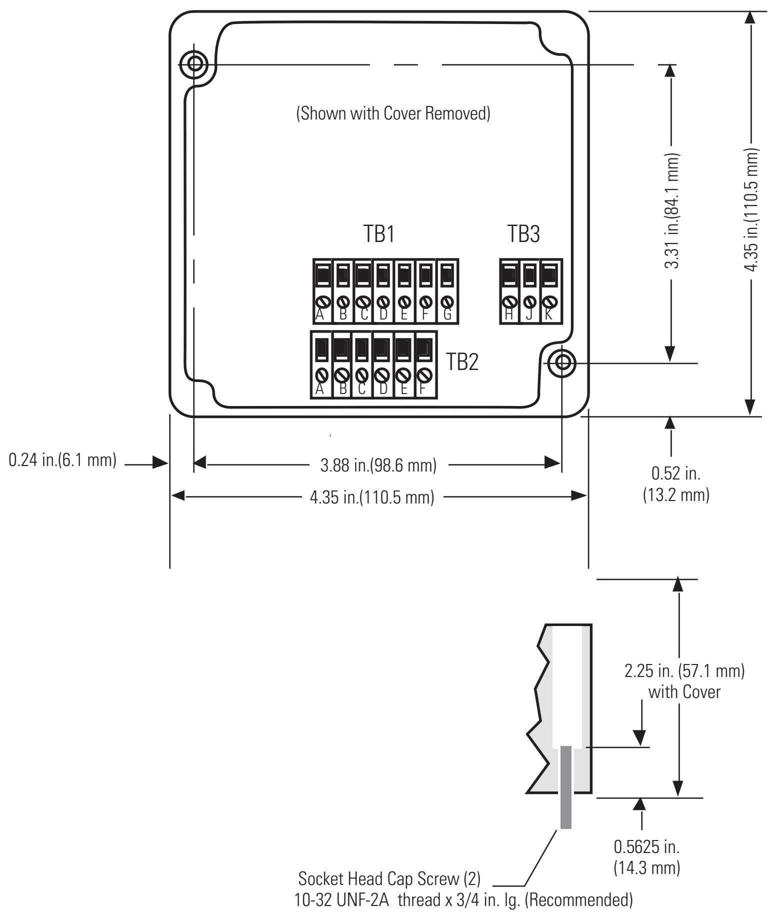


Figure 8-1
AOM Dimensions

1. Mount the AOM in a location within reach of the LDT assembly cable. Standard systems allow the AOM to be mounted 250 feet from the LDT assembly.

2 Connect cable from AOM to the LDT assembly.

3. Adjust the AOM null and full-scale potentiometers (as described in Section 9) to compensate for any offsets due to mechanical installation.

9. Analog Output Module Adjustments

This section explains how to adjust and calibrate the Temposonics II LDT system using an AOM.

The AOM includes adjustments for null (zero), and full-scale (span). The adjustments compensate for the following:

- Differences between transducer gradients.
- Small offsets in the magnet position due to mounting.
- Wear in the moving parts of the mechanical system to which the magnet is attached.

In cases where a coupler device is used for adjusting the magnet, the coupler is used for coarse adjust ments of both null and scale, while the AOM is used for fine adjustments.

9.1 Nominal Range of Adjustment

Null:	*Minimum:* ± 3/8 in.
	Maximum: Up to 10% of total stroke or ±2 inches, whichever is smaller
Full-scale:	± 2% of total stroke

Figure 9-1 (next page) shows the location of position adjustments and terminal boards on the AOM.

NOTE:

Null adjustment has an overall effect on total scale adjustment. However, scale adjustment has no effect on null adjustment.

9.2 Null and Full-Scale Adjustments

The following procedures calibrate the null position and the full-scale position to the required output levels. Refer to Figure 9-1 for the adjustment locations.

NOTE:

The following procedure assumes the standard full-scale 0 to 10 Vdc output is supplied. When other output signals are supplied, use the appropriate signal levels and test equipment for the following adjustments.

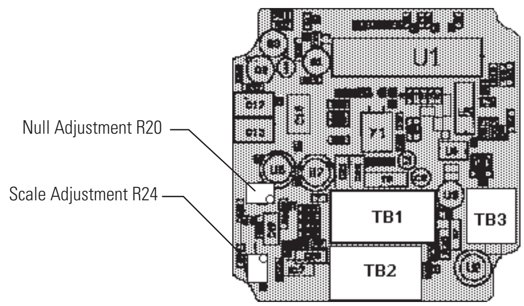


Figure 9-1
Location of Null & Scale Adjustments
and Terminal Boards on the AOM.

1. Disconnect all power from the system. Loosen the four screws securing the AOM cover, and remove the cover.

2. Note the location of terminal board TB1 on the AOM (Refer to Figure 9-1). Connect a DVM (digital voltmeter) across pins A and B of terminal board TB1 to monitor the displacement signal. Apply power to the system

3. Position the permanent magnet at the specified null position. The null position is specified when the LDT assembly is ordered (typically 2 inches from the transducer head).

4. Use a screwdriver to adjust the null potentiometer (R20) to increase or decrease the value, until you obtain a DVM reading of 0.000 Vdc.

5. Position the permanent magnet for full-scale position (typically 2 inches from the end of the LDT assembly).

6. Use a screwdriver to adjust the scale potentiometer (R24) to increase or decrease the value, until you obtain a DVM reading of +10.000 Vdc.

7. Repeat steps 3 to 6 to check the null and full-scale settings. Readjust as necessary.

8. Disconnect the DVM and check overall system operation. If no more adjustments are necessary, replace the AOM cover.

9.3 Velocity Null Adjustment

The AOM can be provided with an optional velocity output. For those units, velocity zero and span adjustments are provided. The velocity zero and velocity span adjustments are factory set and should not require readjustment. A velocity output signal of 0 (zero) volts represents a static displacement (no motion). A velocity output of 10 volts represents a dynamic displacement or a customer-specified maximum velocity (maximum velocity must be specified at time of order). The direction of motion is indicated by the polarity of the velocity signal; a positive output signal typically indicates that the permanent magnet is moving away from the transducer head (unless otherwise specified for this system). A negative output signal typically indicates that the permanent magnet is moving towards the transducer head.

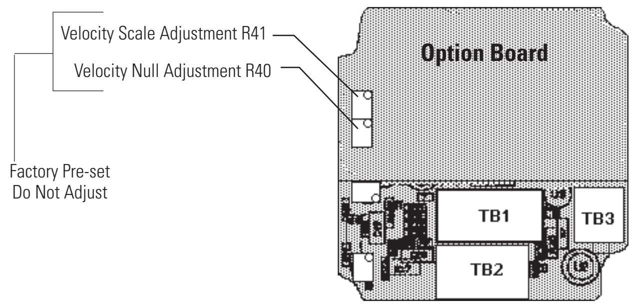


Figure 9-2
Velocity Adjustments on the AOM

10. Analog Output Module/ Wiring Procedures

This section describes wiring procedures for analog systems that use the Analog Output Module, including:

- 0 to 10 V displacement (forward and reverse acting)
- -10 to +10 V displacement (forward and reverse acting)
- Ungrounded 4 to 20 mA displacement
- Grounded 4 to 20 mA displacement
- Velocity Outputs
- Dual Channel Outputs

Connections are made between the transducer assembly, the AOM, the customer-supplied power supply, and the customer-supplied receiving device.

10.1 Preparing Cable for Connection to the AOM

The AOM is equipped with two strain relief or two MS (mil-spec) connectors.

A strain relief is used for an un-terminated cable. Prepare the cable as shown in Figure 10-1. It is recommended that you tin the exposed leads to ensure a good connection. Mount the cable to the AOM, ready to make connections to the terminal boards (TB1, TB2, or TB3) inside.

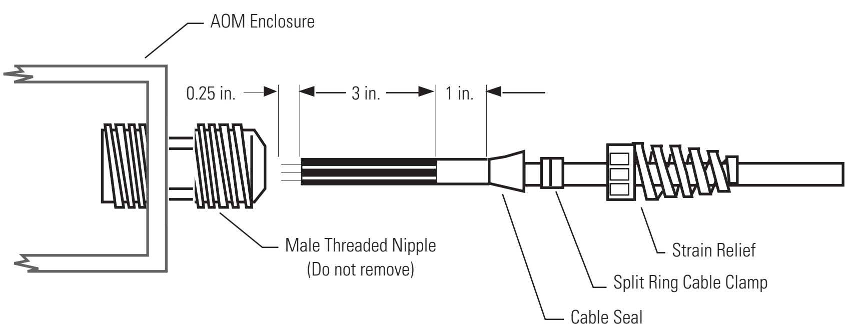


Figure 10-1
Cable Preparation for Strain Relief

When the AOM box is used an optional MS connector can be used with the cable. Cables are available in various lengths from inventory.

10.2 J1 Installation Wiring

The J1 cable provides the AOM voltage inputs from the DC power supply. It also provides displacement outputs to the receiving device.

Take the following steps to connect J1:

1. One of the screws securing the cover of the AOM has a raised head. Connect a ground wire from that screw head to a central earth ground or to the power supply ground (if it is grounded). Only one circuit earth ground should be used to prevent ground loops. (Refer to Figure 5-1 of this manual for a full system grounding diagram.)

2. Strain Relief Only: Fabricate the J1 cable, and prepare the cable as described earlier. Identify the connections to TB1 and TB3. Refer to section 10.3 to determine the appropriate J1 connections.

3. MS Connector Only: Fabricate the J1 cable. Refer to section 10.4 to determine the appropriate J1 connections. Solder the connections to the MS type connector (Part No. 370017). Use any cable capable of maintaining the signals for the required length. Ensure the solder connections are clean and free of excessive solder. Use heat-shrink over the solder connections to prevent the pins from shorting.

4. Identify the wires at the other end of the cable for connections to the power supplies and the receiving device. Test the cable for shorts.

> **NOTE:**
>
> *Make sure that the power supply can provide +15 Vdc at 250 mA and -15 Vdc at 65 mA (use a bipolar power supply). The power supply should provide less than 1% ripple with 2% regulation. The power supply should be dedicated to the transducer system to prevent noise and external loads from affecting the system performance.*

5. Make sure the power supply is off. Complete the cable connections at the power supply.

> **! CAUTION !**
>
> *The input to the receiver electronics should be a passive, resistive device to prevent damage to the AOM.*

6. First, make sure there is no voltage present on the receiving device input connections. Then, complete the cable connections to the receiving device.

> **NOTE:**
>
> *Do not route the J1 cable near high voltage sources.*

7. Strain Relief Only: Connect the cable to the TB1 and TB3 terminals on the AOM.

8. MS Connector Only: Connect the cable to the J1 connector on the AOM.

10.3 J1 Connections for AOM

The AOM is provided with either a strain relief connector, which accepts a pigtailed connection directly into terminals blocks located inside the AOM enclosure, or a threaded MS connectors. Tables 10A through 10F, below, indicate the appropriate connection to make for either configuration. Make sure that you follow the appropriate table for your specified options.

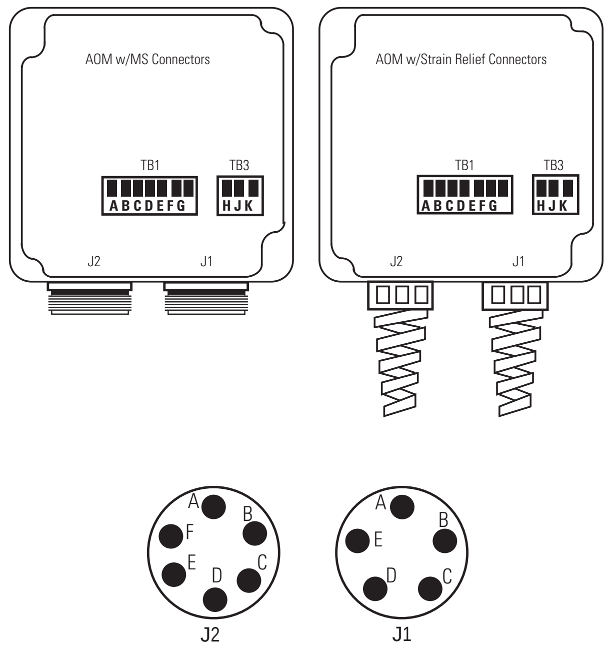


Figure 10-2
AOM w/ Strain Relief and MS Connectors

Table 10A Standard J1 Connections

Strain Relief Connection	*MS Connector Pin Designation (J1)*	*Function*
TB1		
A	D	Displacement Output
B	E	Displacement Output Return (ground)
TB3		
H	A	+ 15 Vdc
J	B	- 15 Vdc
K	C	DC Common

Table 10B J1 Connections w/Velocity Output Option

Strain Relief Connection	*MS Connector Pin Designation (J1)*	*Function*
TB1		
A	D	Displacement Output
B	-	Displacement Output Return (ground)
C	E	Velocity Output
D	-	Velocity Output Return (ground)
TB3		
H	A	+ 15 Vdc
J	B	- 15 Vdc
K	C	DC Common

Table 10C J1 Connections w/24 V Power Supply Option

Strain Relief Connection	*MS Connector Pin (J1)*	*Function*
TB1		
A	D	(+) Displacement Output
B	E	(-) Displacement Output
TB3		
H	A	24 Vdc
J	No Connection	N/A
K	C	DC Common

Table 10D J1 Connections w/ 24 V Power Supply & Velocity Output Options

Strain Relief Connection	*MS Connector Pin (J1)*	*Function*
TB1		
A	D	(+) Displacement Output
B	-	(-) Displacement Output
C	E	(+) Velocity Output
D	-	(-) Velocity Output
TB3		
H	A	24 Vdc
J	No Connection	N/A
K	C	DC Common

Table 10E AOM J1 Connections w/Dual Channel Option

Strain Relief Connection	*MS Connector Pin (J1)*	*Function*
TB1		
A	D	Channel 1 (+) Displacement Output
E	E	Channel 2 (+) Displacement Output
TB3		
H	A	+ 15 Vdc
J	B	- 15 Vdc
K	C	DC Common

Table 10F J1 Connections w/Dual Channel & 24 V Power Supply Options

Strain Relief Connection	*MS Connector Pin (J1)*	*Function*
TB1		
A	D	Channel 1 (+) Displacement Output
E	E	Channel 2 (+) Displacement Output
TB3		
H	A	24 Vdc
J	No Connection	N/A
K	C	DC Common

10.4 J1 Connection to AOM with MS Connectors

Table 10G Voltage Output

*Terminal Block Connections **	*Pin Connection (J1)*	*Function #1 (w/Standard ± 15 Vdc P.S.)*	*Function #2 (w/Optional + 24 Vdc P.S.)*
TB3-H	A	+ 15 Vdc	+ 24 Vdc
TB3-J	B	- 15Vdc	-
TB3-K	C	DC Common	DC Common
TB3-A	D	Displacement Output	Displacement Output
TB1-B	E	Optional: velocity output	Optional: velocity output

Table 10H Ungrounded 4-20 mA Current Output

*Terminal Block Connections **	*Pin Connection (J1)*	*Function #1 (w/Standard ± 15 Vdc P.S.)*	*Function #2 (w/Optional + 24 Vdc P.S.)*
TB3-H	A	+ 15 Vdc	+ 24 Vdc
TB3-J	B	- 15 Vdc	-
TB3-K	C	DC Common	DC Common
TB1-A	D	Current Output (source) *DO NOT ground or damage may result* *Maximum load resistance: 400Ω*	Current Output (source) *DO NOT ground or damage may result.* *Maximum load resistance: 400Ω*
TB1-B	E	Current Output (return)	Current Output (return)

Table 10I Grounded 4-20 mA Current Output

*Terminal Block Connections **	*Pin Connection (J1)*	*Function #1 (w/Standard ± 15 Vdc P.S.)*	*Function #2 (w/Optional + 24 Vdc P.S.)*
TB3-H	A	+ 15 Vdc	+ 24 Vdc
TB3-J	B	- 15 Vdc	-
TB3-K	C	DC Common	DC Common
TB1-A	D	Current Output (source)	Current Output (source)
-	E	Not Used	Not used
		Maximum load resistance: 500Ω	Maximum load resistance: 500Ω

** Terminal blocks are located inside the AOM housing and are accessed via strain relief connectors J1 and J2 on the face of the AOM.*

10.5 J2 Connections

The J2 cable provides connections between the AOM and the transducer assembly.

Cables up to 250 feet (76 meters) can be fabricated with any high quality multi-conductor cable with an overall shield (Belden equivalent).

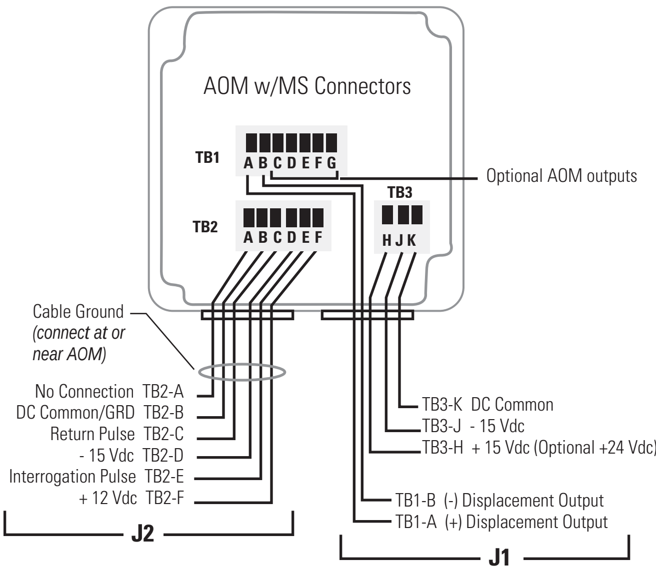
Take the following steps to connect J2:

1. It is recommended that you apply an earth ground to the transducer rod. This is typically accomplished by mounting the transducer head to a bracket or machine.

2. Strain Relief Only: If necessary, fabricate the J2 cable, and prepare the cable as described earlier. Identify the connections to TB2. Refer to Table 10J (next page) for the J2 connections.

> **NOTE:**
>
> *Ensure the solder connections are clean and free of excessive solder. Use heat-shrink over the solder connections to prevent the pins from shorting.*

3. MS Connector Only:
If necessary, fabricate the J2 cable. Be sure to use the recommended cable for the required length. The color code refers to cables supplied with the system. Solder the connections to the MS connector supplied with the AOM. Use any cable capable of maintaining the signals for the required length. Ensure the solder connections are clean and free of excessive solder. Use heat-shrink over the solder connections to prevent the pins from shorting.



NOTE:
The connections to TB3 represent wiring for a typical system configuration (i.e., ±15 Vdc power supply and strain-relief connectors). If the AOM is configured with other options (i.e., 24 Vdc power supply, velocity output, MS connectors) refer to sections 10.3 and 10.4 for proper wiring.

Figure 10.3
AOM J1 and J2 Connections

Table 10J AOM J2 Connections

J2 Connection (TB 2 A - F or J2 Pin A - F)				
Pin Connection	***Terminal Block Connection***	***Wire Color Code ****	***Wire Color Code***	****Function***
J2 Pin A	TB2-A	Not Used	Not Used	No Connection
J2 Pin B	TB2-B	White/Blue Stripe Blue/White Stripe White/Brown Stripe Gray/White Stripe	White Brown Black Green	DC Common/GND Frame
J2 Pin C	TB2-C	Brown/White Stripe	Violet	Output Pulse
J2 Pin D	TB2-D	Green White Stripe	Blue	- 15 Vdc (- 13.5 to - 14.5 Vdc)
J2 Pin E	TB2-E	White/Gray Stripe	Yellow	Interrogation Pulse
J2 Pin F (see note 1)	TB2-F	White/Green Stripe	Red	+12 Vdc

*Verify if the cable has striped or solid color leads and make connections accordingly.

NOTES:
1. Connect to TB2 Pin A if the stoke length exceeds 180 inches.

4. Strain Relief Only: Connect the cable to the TB2 terminals on the AOM and to the transducer.

5. MS Connector Only: Connect the cable to the J2 connector on the AOM, and to the transducer.

6. Apply power and check the displacement readings at the system electronics.

Table 10K Retrofit Connections -

Temposonics II Replacement of Existing Temposonics I with AOM

Temposonics II Integrated or Extension Cable (Notes 1, 2)				**Analog Output Module (AOM)**	
Pin No.	***Wire Color Code***	***Wire Color Code***	***Functional Description***	***Terminal Blocks***	***Military Style (MS) Connectors***
1	White/Blue Stripe	White	DC Ground	TB2-B	J2 Pin B
2	Blue/White Stripe	Brown	Frame (Note 3)	TB2-B	J2 Pin B
3	White/Orange Stripe	Gray	Not Used	Not Used	Not Used
4	Orange/White Stripe	Pink	Not Used	Not Used	Not Used
5	White/Green Stripe	Red	+Vdc	TB2-F (Note 4)	J2 Pin F (Note 4)
6	Green/White Stripe	Blue	-Vdc	TB2-D	J2 Pin D
7	White/Brown Stripe	Black	Return (GND)	TB2-B	J2 Pin B
8	Brown/White Stripe	Violet	Output (return pulse)	TB2-C	J2 Pin C
9	White/Gray Stripe	Yellow (See warning, below)	(+) Interrogation (Note 5)	TB2-E	J2 Pin E
10	Gray/White Stripe	Green (See warning, below)	(-) Interrogation (Note 6)	TB2-B	J2 Pin B

NOTES:
1. Verify if the cable has striped or solid color leads and make connections accordingly.
2. Cable: Belden #8105 or equivalent
3. Frame ground is isolated from circuit ground inside the electronics enclosure or head of the transducer.
4. Connect to TB2 Pin A if the stoke length exceeds 180 inches.
5. For retrofitting AOMs with stoke lengths greater than 12 inches in stroke length and positive (+) interrogation.
6. For retrofitting AOMs with stoke lengths greater than 12 inches in stroke length and negative (-) interrogation.
7. Shield: Connect extension cable shield at TB2-B or J2 Pin B.

!WARNING!

Under no condition connect both the positive (+) and negative (-) interrogation wires to TB2-E at the same time. The unused interrogation lead MUST be connected to DC Ground.

11. Troubleshooting the Analog Output Module

Use the troubleshooting procedures in this section when operational problems are encountered. The procedures are listed in order of frequency of occurrence, and should be completed in the order shown.

> **NOTE:**
> *The following procedures are for general diagnostic purposes. Purchase of replacement components should not be based solely on these procedures. Consult MTS Sensors Division for recommendations and factory service before ordering replacement components.*

11.1 General

Make sure the magnet is positioned to move freely along the LDT rod. Trace all wiring from the J1 connector to ensure proper routing.

11.2 Power Supply Check

Perform the following procedure to check the power supply voltages.

1. Remove power and disconnect connector J1 to check open circuit power supply voltages (as described in steps 2 and 3).

> **NOTE:**
> *If voltage is not present in steps 2 and 3, a problem with wiring or the power supply is indicated.*

2. Connect a DVM (digital voltmeter) to pins A and C of cable connector J1 if you have MS type connectors, or TB3 pins H and K if you have strain relief connectors. Apply power. The voltage should be +15 Vdc.

3. Connect the DVM to pins B and C of cable connector J1 if you have MS type connectors, or TB3 pins J and K if you have strain relief connectors. The voltage should be -15 Vdc.

> **NOTE:**
> *A low voltage reading in steps 4 and 5 indicates a power supply with an inadequate rating or an excessive voltage drop in the cabling (i.e. improper wire sizes).*

4. If the voltage readings are correct, check the power supply voltages under load (as described in steps 5 and 6).

5. Connect a 60 Ω to 75 Ω resistor across Pins A and C of the MS connector or pins H and K of TB3. The voltage across the resistor should be +14.7 Vdc (minimum).

6. Connect a 230 Ω to 250 Ω resistor across Pins B and C. The voltage across the resistor should be -14.7 Vdc (minimum).

11.3 Grounding

Trace all ground and power supply common connections. A single earth ground should be connected to the power supply common (circuit ground). An additional ground is connected to the case of the analog output module (AOM). If the AOM is suspect, remove the mounting screws and place the box on insulating material (i.e. wood) then recheck the output readings.

11.4 Connections

Check the solder connections in the J1 cable. Ensure no cold solder joints are present. Perform a continuity check between the J1 connections to ensure no shorts are present.

11.5 LDT Signals

Disconnect connector J2 from the AOM. Apply power and check the J2 readings, using Figure 11-1. If the voltages are correct, connect J2 and check the signals at pins B and C with an oscilloscope.

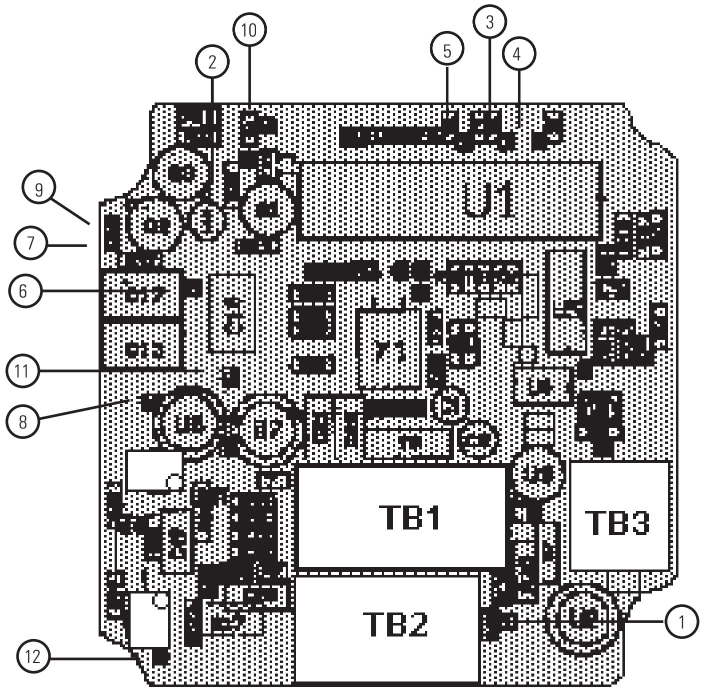
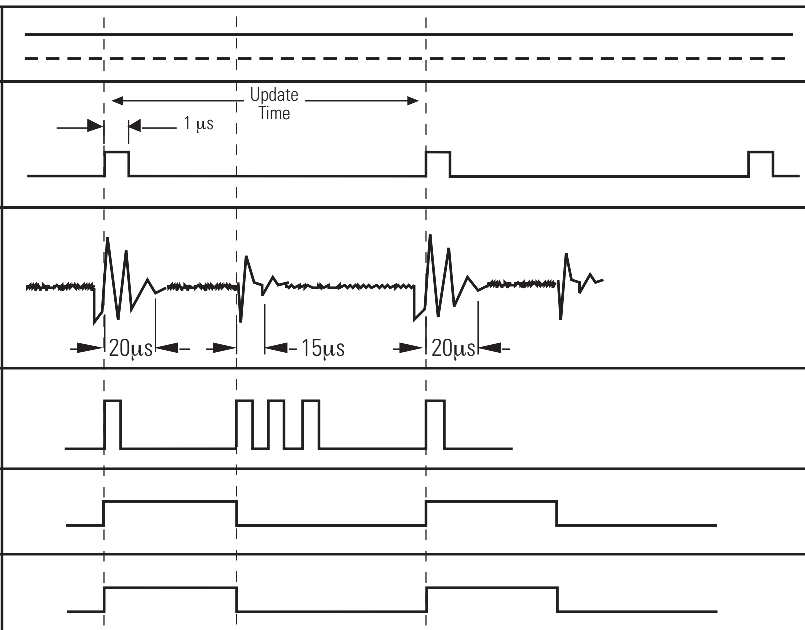


Figure 11-1
Test Point (TP) Locations



A		5 Volts at Test Point 1 0 Volts, TB3-K
B		3 - 5 Volt Interrogation pulse sent to TB2-E
C		Pulse returned from TB2-C (approximately 2-3 Volts)
D		TTL level pulse, 3-5 Volts located at Test Point 3
E		Pulse-width modulated output 3-5 Volts at Test Point 2
F		6 Volts at Test Point 6
G	Test Point #9: 0 to 10 Volts as the magnet moves back and forth.	
H	Test Point #12: 0 to10 Volts or ±10 volts as the magnet moves back and forth. (The 4-20 mA Ungrounded option is 0 to 2 Volts)	
I	TB1-A: Same as H, above.	

Figure 11-2
AOM Signals

NOTE:

Do not interchange transducers and AOMs with differing model numbers, without first consulting MTS Sensors Division.

A. If a spare transducer of the same stroke and model number is available, connect the spare transducer to the AOM and check the displacement readings at the system electronics.

B. If a spare AOM of the same stroke model number is available, connect J1, J2 and the ground wire to the spare AOM and check the displacement readings at the system electronics.

12. Analog Output Card

The Analog Output Card is a plug-in type electronics card that performs the same functions as the Analog Output Module (AOM) and can be used as a direct replacement (physically and functionally) for the "old style" Temposonics Electronics Card.

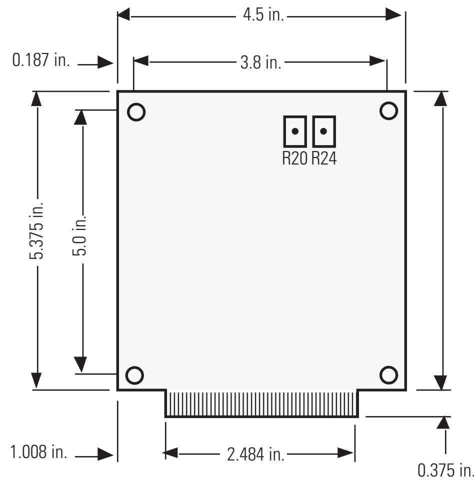


Figure 12-1
Analog Output Card Dimensions

The displacement output options available from the Analog Output Cards are as follows:

Voltage Outputs:
- 0 to 10 Vdc (forward and reverse acting)
- 0 to -10 Vdc (forward and reverse acting)
- -10 to +10 Vdc (forward and reverse acting)

Current Outputs:
- 4 to 20 mA ungrounded (forward and reverse acting)
- 4 to 20 mA grounded (forward and reverse acting)

Null (R20) and scale (R24) adjustments are available on the Analog Output Card.

Null Adjustment:
Using a digital voltmeter, turn potentiometer (R20) to increase or decrease the voltage output until null is set at 0.000 Vdc.

Scale Adjustment:
Using a digital voltmeter, turn potentiometer (R24) to increase or decrease the voltage output until full scale output is set at 10.000 Vdc.

The Analog Output Card has a 15 pin edge card connector, the function of each pin is as follows:

Table 12A

Analog Output Card Pin Identification

Pin No.	*Function*
1	DC Ground (Current return for grounded systems)
2	+5 Vdc input (optional)
3	- 15 Vdc input
4	+12 Vdc to transducer (for strokes < 180 in.)
5	+15 Vdc input (+24 Vdc is optional)
6	+15 Vdc to transducer (for strokes ≥ 180 in.)
7	External reference input (optional)
8	-15 Vdc to transducer
9	+ Pulse width modulated signal (optional)
10	Dependent upon unit configuration. Options include: • 4-20 mA ungrounded velocity return, or • Channel 2 return for dual channel displacement
11	Dependent upon unit configuration. Options include: • Velocity output (current source), or • Channel 2 output for dual channel displacement
12	Analog displacement output (current source)
13	Displacement return for 4-20 mA ungrounded output systems
14	Output pulse
15	+ Interrogation pulse to transducer

NOTE:
The mating edge connector is MTS p/n 370034, and may be ordered by contacting the factory.

The connections from the Temposonics II transducer to the Analog Output Card are as follows:

Table 12B

Temposonics II Connection to Analog Output Card

Temposonics II Integrated or Extension Cable (see Note 1)			
Pin No.	*Wire Color Code*	*Wire Color Code*	*Analog Output Card Pin No.*
1	White/Blue Stripe	White	1
2	Blue/White Stripe	Brown	1
5	White/Green Stripe	Red	4
6	Green/White Stripe	Blue	8
7	White/Brown Stripe	Black	1
8	Brown/White Stripe	Violet	14
9	White/Gray Stripe	Yellow	15
10	Gray/White Stripe	Green	1

NOTES:
1. Verify if the cable has striped or solid color leads and make connections accordingly.
2. Shield wire (drain) can be connected to Pin 1 on the Analog Output Card.

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Part Number: 11-98 550032 Revision F

Sensors Division

Temposonics® II

Linear Displacement Transducer

Installation and Instruction Manual for

DIGITAL SYSTEMS

P/N 550033 Rev. F

GENERAL INFORMATION

MTS PHONE NUMBERS

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APPENDICES

1. Introduction to the Temposonics II Linear Displacement Transducer (LDT)

The Temposonics II LDT precisely senses the position of an external magnet to measure displacement with a high degree of accuracy and resolution. Using the principle of magnetostriction (see Section 1.1, below), the Temposonics II LDT measures the time interval between the initiation of an interrogation pulse and the detection of a return pulse. A variety of interface devices use the data derived from these two pulses and generates an analog or digital output to represent position.

1.1 Theory of Operation/Magnetostriction

The interrogation pulse travels the length of the transducer by a conducting wire threaded through a hollow waveguide. The waveguide is spring loaded within the transducer rod and exhibits the physical property of magnetostriction. When the magnetic field of the interrogation pulse interacts with the stationary magnetic field of the external magnet, a torsional strain pulse or "twist" is produced in the waveguide. This strain pulse travels in both directions, away from the magnet. At the end of the rod, the strain pulse is damped within the "dead zone" (2.5 inches in length). At the head of the transducer, two magnetically coupled sensing coils are attached to strain sensitive tapes. The tapes translate the strain pulse through coils to an electrical "return pulse". The coil voltage is then amplified in the head electronics before it is sent to various measuring devices as the conditioned "return pulse".

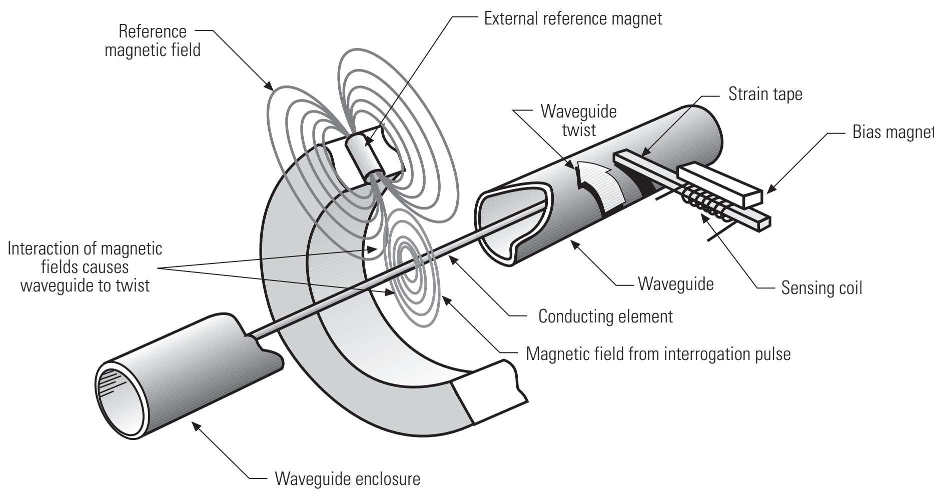


Figure 1-1
Waveguide Interaction

1.2 Temposonics II LDT Specifications

Parameter	***Specifications***
Input Voltage:	± 12 to ± 15 Vdc
Current Draw:	***Transducer Only:*** ± 15 Vdc at 100 mA maximum, 25 mA minimum (current draw varies with magnet position, maximum draw occurs when magnet is at 2 in. (50.6 mm) from the flange and minimum update time is being utilized) ***Transducer with:*** • RS-422 Personality Module (RPM): ± 12 to ±15 Vdc at 140 mA maximum • Digital Personality Module (DPM): + 15 Vdc at 150 mA maximum, 75 mA minimum, - 15 Vdc at 100 mA maximum, 25 mA minimum
Displacement:	Up to 25 feet (7620 millimeters)
Dead Space:	2.5 inches (63.5 millimeters) for stroke lengths up to 179.9 in. 3 inches (76.2 millimeters) for stroke lengths ≥ 180 in.
Electronics Enclosure:	IP-67
Non-linearity:	< ± 0.05% of full scale or ± 0.002 inch (±0.05 mm), whichever is greater
Resolution:	1 ÷ [gradient x crystal freq. (mHz) x circulation]; maximum resolution: 0.006 mm or 0.00025 in.
Repeatability:	Equals resolution
Hysteresis:	0.0008 inch (0.02 mm) maximum
Update Time:	Resolution and Stroke dependent Minimum = [Stroke (specified in inches) + 3] x 9.1 µs
Operating Temperature Head Electronics: Transducer Rod:	 - 40 to 150°F (- 40 to 66°C) - 40 to 185°F (- 40 to 85°C)
Operating Pressure:	3000 psi continuous, 8000 psi static
Digital Outputs (absolute)	TTL level, nominal 0 and 5V, true high, parallel transmission

Specifications are subject to change without notice. Consult MTS for verification of specifications critical to your application.

1.3 Specifications for Temposonics II LDTs over 180 Inches

Below is a list of specifications that pertain to Temposonics II transducers with active stroke lengths of 180 inches (4572 mm) to 300 inches (7620 mm). Special versions of the Analog Output Modules (AOM) and Digital Interface Boxes (DIB) are required to interface with transducers over 180 inches in length. Contact an MTS Applications Engineer for details before ordering.

Parameter	***Specifications***
Input Voltage:	• Maximum: ± 15 Vdc, ± 5% at 100 mA • Minimum: ± 15 Vdc at 25 mA (current draw varies with magnet position, maximum draw occurs when magnet is 2 inches (50.8 mm) from the flange and minimum update time is being used)
Dead Space:	3 in. (76.2 mm)
Cable Length:	• Maximum cable length for neuter version transducer (i.e., Temposonics II without an integrated Personality Module) which requires the use of external interface electronics (Analog output Module, Digital Interface Box or other signal conditioners) is 250 ft. • Maximum cable length for Temposonics II transducers with Personality Modules RPM: 1640 feet (500 meters) using external interrogation DPM: 300 feet (90 meters) using external interrogation
Magnet Requirement:	Part Number: 201554 or 201553 ONLY

2. Temposonics II LDT Installation

Before beginning installation, be sure you know the following dimensions (as illustrated in Figures 2-1 to 2-3a-c.):

- Null Space
- Stroke
- Dead Zone

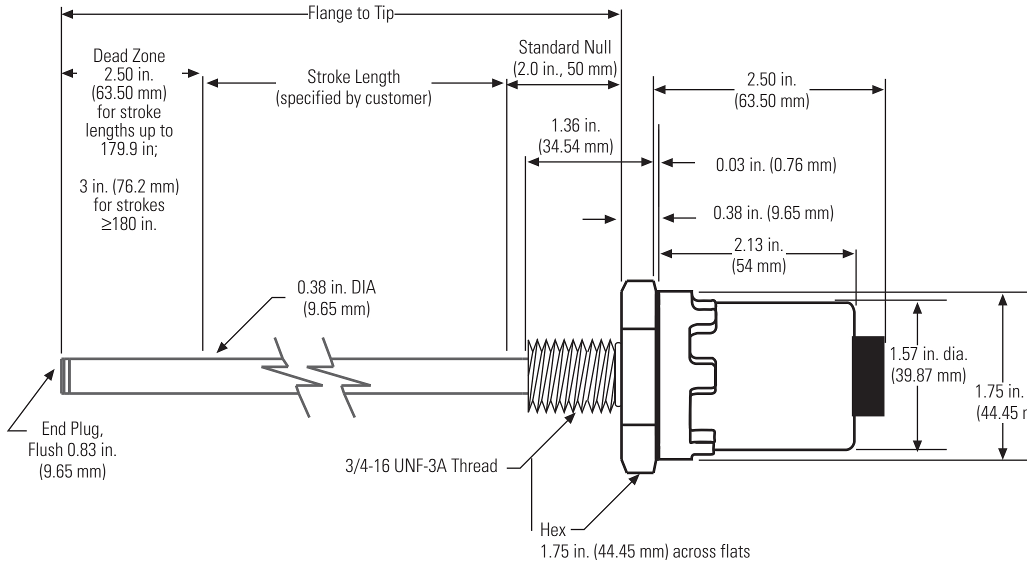


Figure 2-1
Temposonics II Dimension

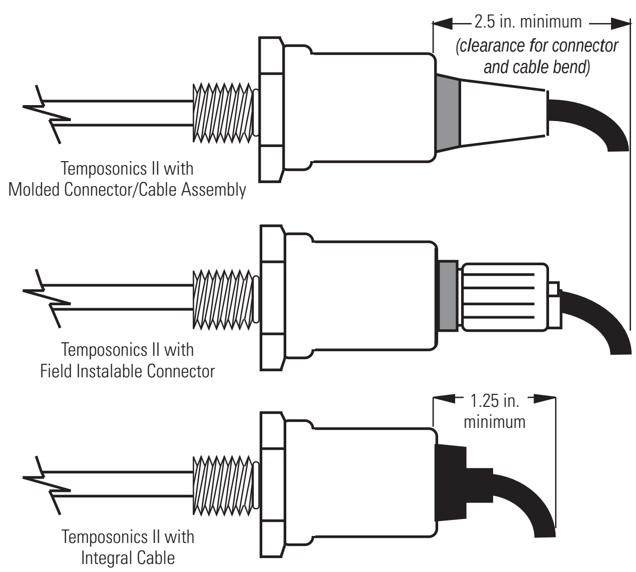


Figure 2-2
Temposonics II Connector/Cable Clearance Requirements

1. Use the 3/4 inch (19 mm), 16 UNF thread of the transducer to mount it at the selected location. Leave room to access the hex head. If a pressure or moisture seal is required, install an O-ring (type MS 28778-8 is recommended) in the special groove. Use the hex head to tighten the transducer assembly.

2. Install the permanent magnet over the LDT rod. Mount the permanent magnet to the movable device whose displacement will be measured. To minimize the effect of magnetic materials (i.e. iron, steel, etc.) on the magnetic field of the permanent magnet, ensure the minimum spacing requirements are met as shown in Figure 2-4. (Any non-magnetic materials can be in direct contact with the permanent magnet without affecting performance.)

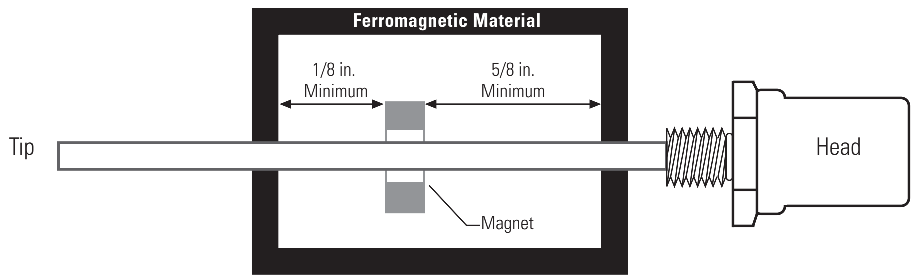


Figure 2-3a
Minimum Magnet Clearance Using Magnetic Supports

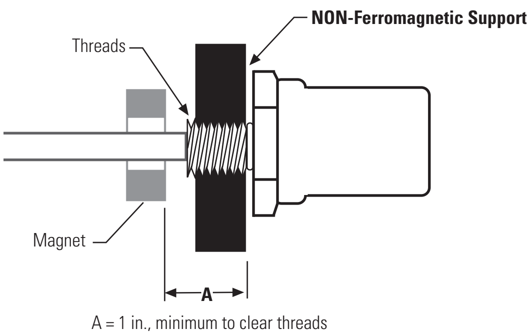


Figure 2-3b
Minimum Null Space Using Non-Magnetic Support

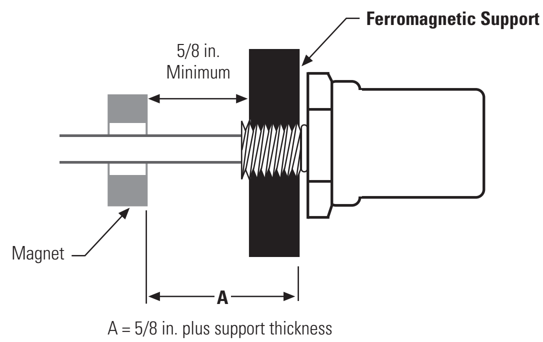


Figure 2-3c
Minimum Null Space Using Magnetic Support

Notes:
1. The magnet must not contact ferromagnetic materials (such as iron or steel). Clearances are required between the surface of the magnet and ferromagnetic material, as shown. Non-ferrous material (such as copper, brass, or 300 series stainless steel) may contact the magnet without affecting transducer performance.
2. Standard Null Space is 2 inches. There is no maximum limit for Null Space. Less then 2 inches can be specified if magnet clearances meet requirements illustrated above.

> **NOTE:**
>
> *Clearance between the magnet and the transducer rod is not critical. However, contact between the components will cause wear over time. The installation of supports or readjustment of the supports is recommended if the magnet contacts the transducer rod.*

4. Move the permanent magnet full-scale to check that it moves freely. If not (if the magnet rubs on the transducer) you can correct this by mounting a support bracket to the end of the transducer. Long transducers may need additional supports to be attached to the transducer rod. Transducer supports are described later in this section.

2.1 Types of Transducer Supports

Long transducers (48 inches or longer) may require supports to maintain proper alignment between the transducer rod and the permanent magnet. When transducer rod supports are used, special, open-ended permanent magnets are required.

Transducer supports attached to the active stroke length must be made of a non-ferrous material, thin enough to permit the permanent magnet to pass without obstruction. Because the permanent magnet does not enter the dead zone, supports connected within the dead zone may be made of any material. The main types of supports are loop, channel, and guide pipe supports.

2.1.1 Loop Supports

Loop supports are fabricated from non-ferrous materials, thin enough to permit free movement of the magnet. Loop supports are recommended for straight transducers. They may be used alone or with channel supports. Figure 2-4 illustrates the fabrication of a loop support.

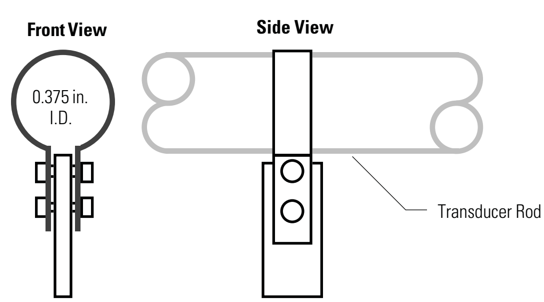


Figure 2-4
Loop Support

> **NOTE:**
>
> *When open magnets are used, ensure the transducer rod remains within the inside diameter of the magnet throughout the length of the stroke. If the transducer rod is allowed to enter the cut out area of an open magnet, the transducer signal could attenuate or be lost. See Figure 2-7.*

2.1.2 Channel Supports

Channel supports, being typically straight, are normally used with rigid transducers. A channel support consists of a straight channel with loop supports mounted at intervals. The loop supports are required to keep the transducer within the channel. Figure 2-5 shows a channel support. Channel supports are available from various manufacturers or may be fabricated.

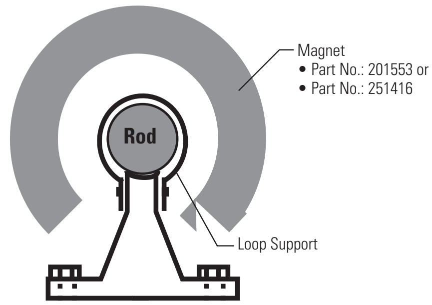


Figure 2-5
Channel Support

2.1.3 Guide Pipe Supports

Guide pipe supports are normally used for flexible transducers. A guide pipe support is constructed of non-ferrous material, straight or bent to the desired shape. As shown in Figure 2-6, both inside and outside dimensions of the pipe are critical:

- Because the transducer rod is installed inside the pipe, the inside diameter of the pipe must be large enough to clear the rod.

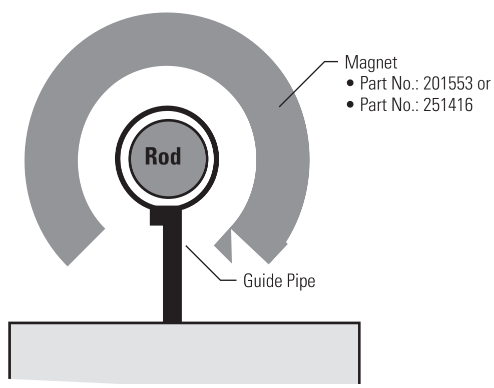


Figure. 2-6
Guide Pipe Support

- The outside diameter of the pipe must be small enough to clear the magnet.

Refer to pipe manufacturers' specifications and dimensions (schedule 10, 40, etc.) to select the appropriate size pipe. Guide pipe is typically supported at each end of the pipe.

2.2 Open Magnets

When using an open magnet, make sure the rod is positioned at all times within the “active” zone of the magnet. The transducer cannot operate properly unless the entire stroke of the transducer rod is located within this zone. The active zone, as shown in Figure 2-7, lies within the inside diameter of the magnet.

Figure 2-7
Active Zone for Open Magnets

2.3 Spring Loading or Tensioning

The transducer rod (flexible or rigid) can be spring loaded or tensioned using a stationary weight. Attach a spring mechanism or weight to the dead zone of the transducer rod with a clamping device which will not deform the transducer rod. The maximum weight or spring tension is 5 to 7 lbs.

2.4 Cylinder Installation

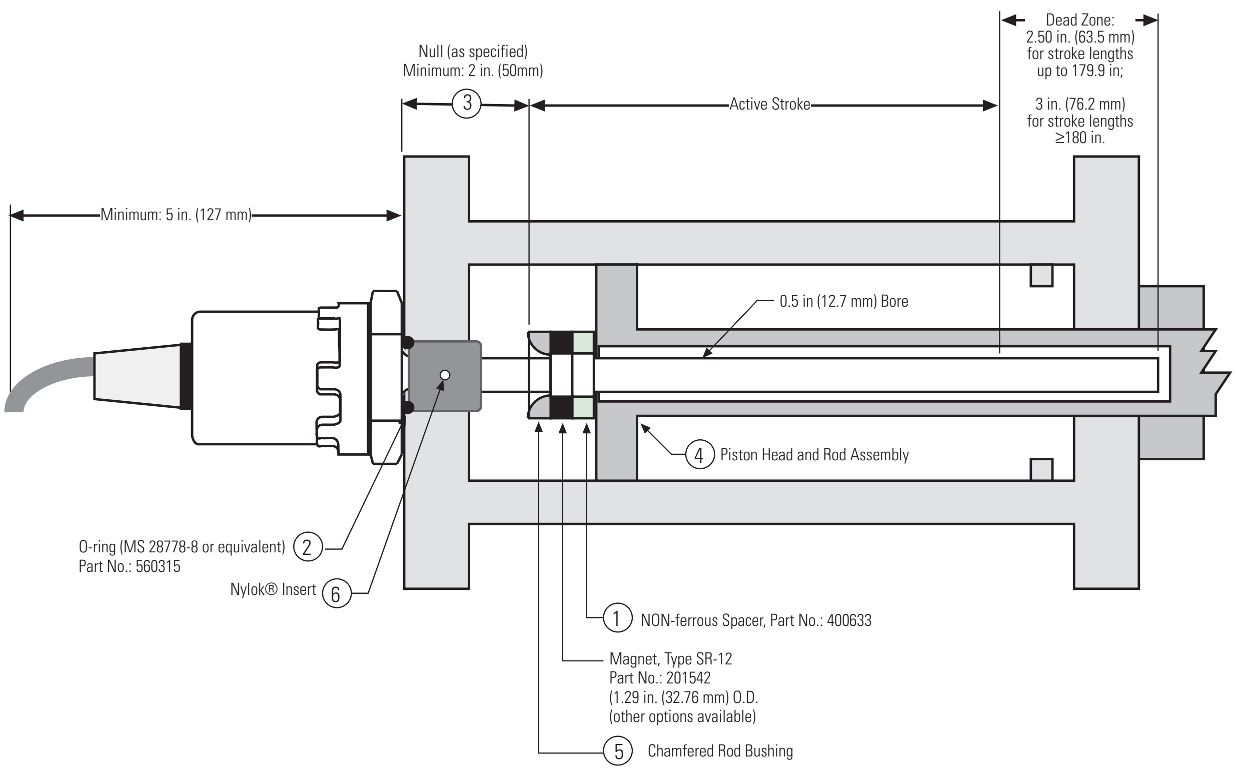
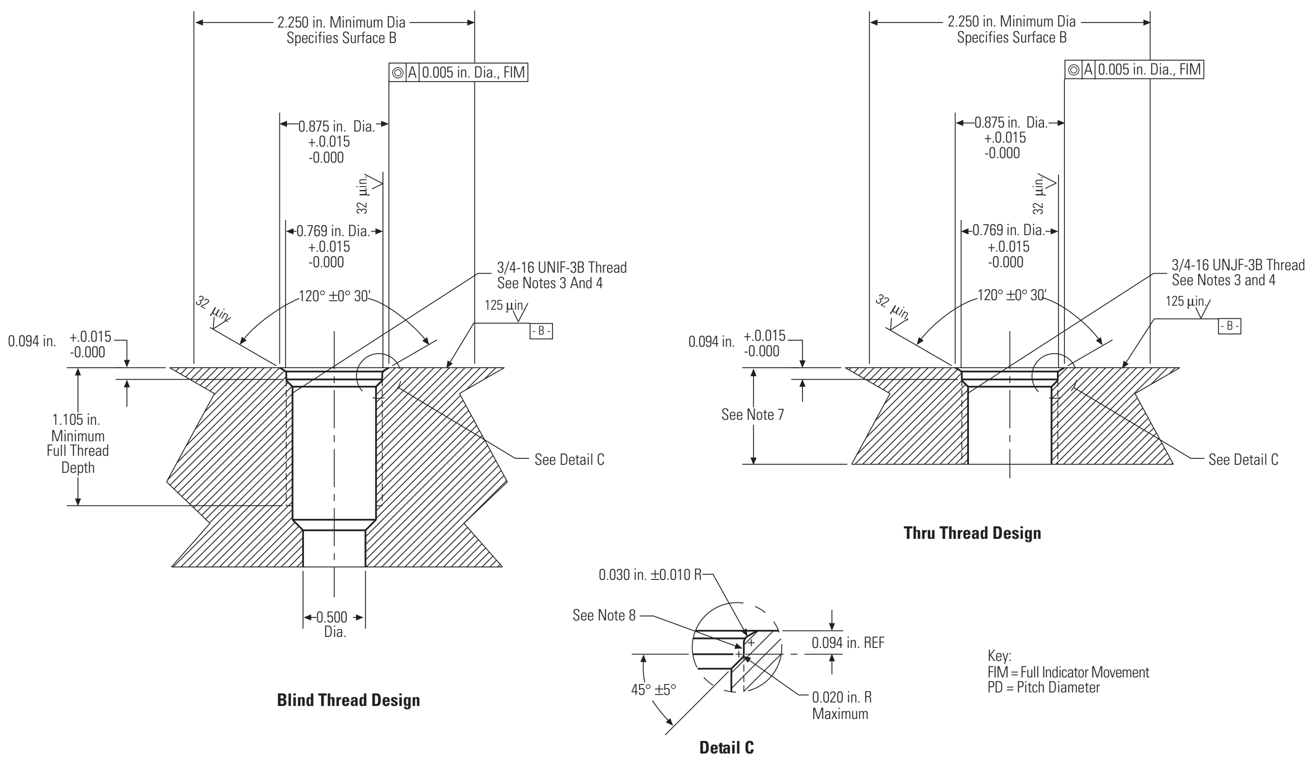


Figure 2-8
Typical Cylinder Installation

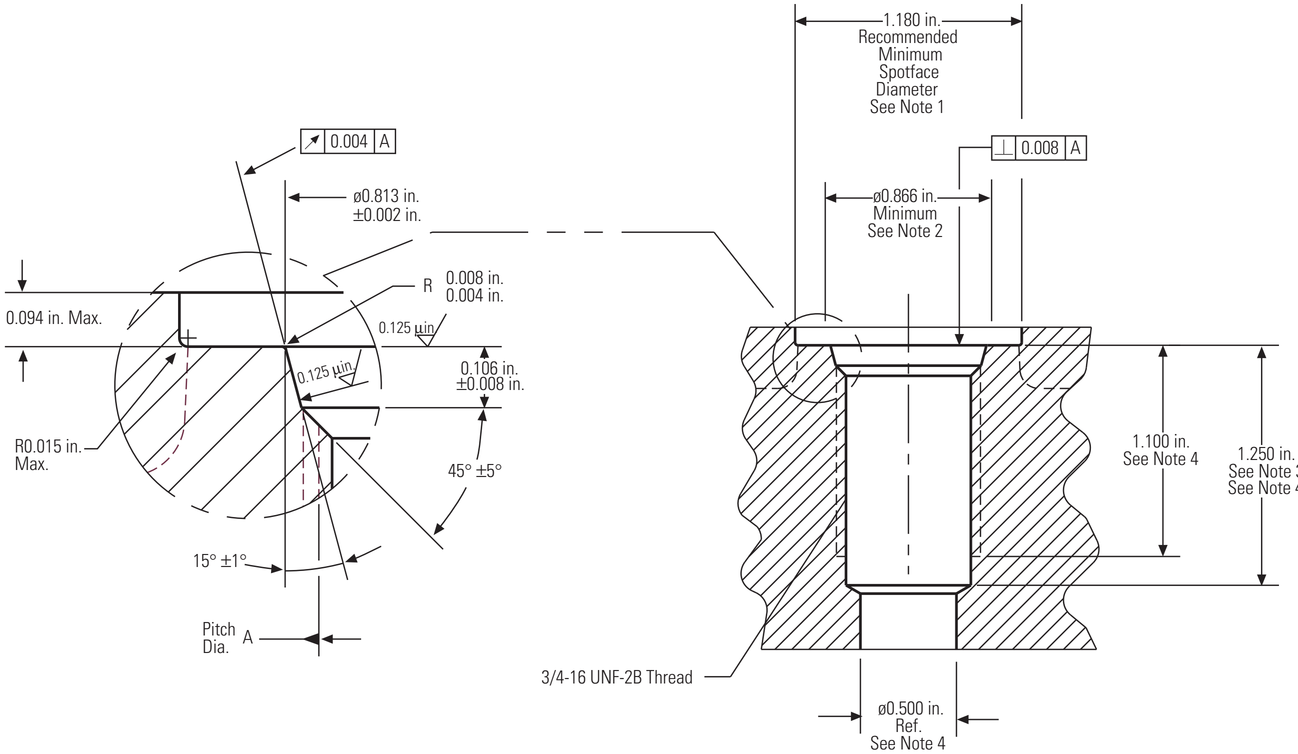
Figure 2-8 shows a typical cylinder installation. Review the following before attempting this type of installation.

- Use a non-ferrous (plastic, brass, Teflon®, etc.) spacer [1] to provide 1/8 inch (32 mm) minimum space between the magnet and the piston.
- An O-ring groove [2] is provided at the base of the transducer hex head for pressure sealing. MTS uses mil-standard MS33514 for the O-ring groove. Refer to mil-standard MS33649 or SAE J514 for machining of mating surfaces.
- The null space [3] is specified according to the installation design and cylinder dimensions. The analog output module provides a null adjustment. Make sure that the magnet can be mounted at the proper null position.
- The piston head [4] shown in Figure 2-8 is typical. For some installations, depending on the clearances, it may be desired to countersink the magnet.
- A chamfered rod bushing [5] should be considered for stokes over 5 feet (1.5 meters) to prevent wear on the magnet as the piston retracts. The bushing should be made from Teflon or similar material.
- A Nylok self locking insert [6] is provided on the transducer threads. An O-ring groove is provided at the base of the transducer hex head for pressure sealing.
- The recommended bore for the cylinder rod is 1/2 inch (13 mm). The transducer rod includes a 0.375 inch flush (9.53 mm) end plug. Use standard industry practices for machining and mounting of all components. Consult the cylinder manufacturer for applicable SAE or military specifications.



NOTES:
1. Dimensions and tolerances based on ANSI Y14.5-1982.
2. MTS has extracted all pertinent information from MS33649 to Generate this document.
3. PD must be square with surface B within 0.005 FIM across 2.250 dia minimum.
4. PD must be concentric with 2.250 dia within 0.030 FIM and with 0.769 dia within 0.005 FIM.
5. Surface texture ANSI B46.1-1978
6. Use o-ring MTS part number 560315 for correct sealing.
7. The thread design shall have sufficient threads to meet strength requirements of material used.
8. Finish counter-bore shall be free from longitudinal and spiral tool marks. Annular tool marks up to 32 micro-inches maximum will be permissible.

Figure 2-9a
O-ring Boss Detail



NOTES:

1. If face of port is on a machined surface, dimensions 1.180 and 0.094 need not apply as long as R0.008/0.004 is maintained to avoid damage to the O-ring during installation.
2. Measure perpendicularity to A at this diameter.
3. This dimension applies when tap drill cannot pass through entire boss.
4. This dimension does not conform to SAE J1926/1.

Figure 2-9b
Port Detail (SAE J1926/1)

2.5 Installing Magnets

Figure 2-10 below shows the standard magnet types and dimensions. The circular magnet with an outside diameter of 1.29 inches and 0.53 inch inside diameter (Part No. 201542) is the most common and is suitable for most applications. Larger magnets, with an outside diameter of 2.5 inches are typically only used with Temposonics transducers that exceed 180 inches in stroke length. Magnets with a 90 degree cut-out are used in applications that require intermediate supports along the transducer rod.

If upon installation, the null adjustment is inadequate, you can design a coupler with adjustments to mount the magnet to the measured member.

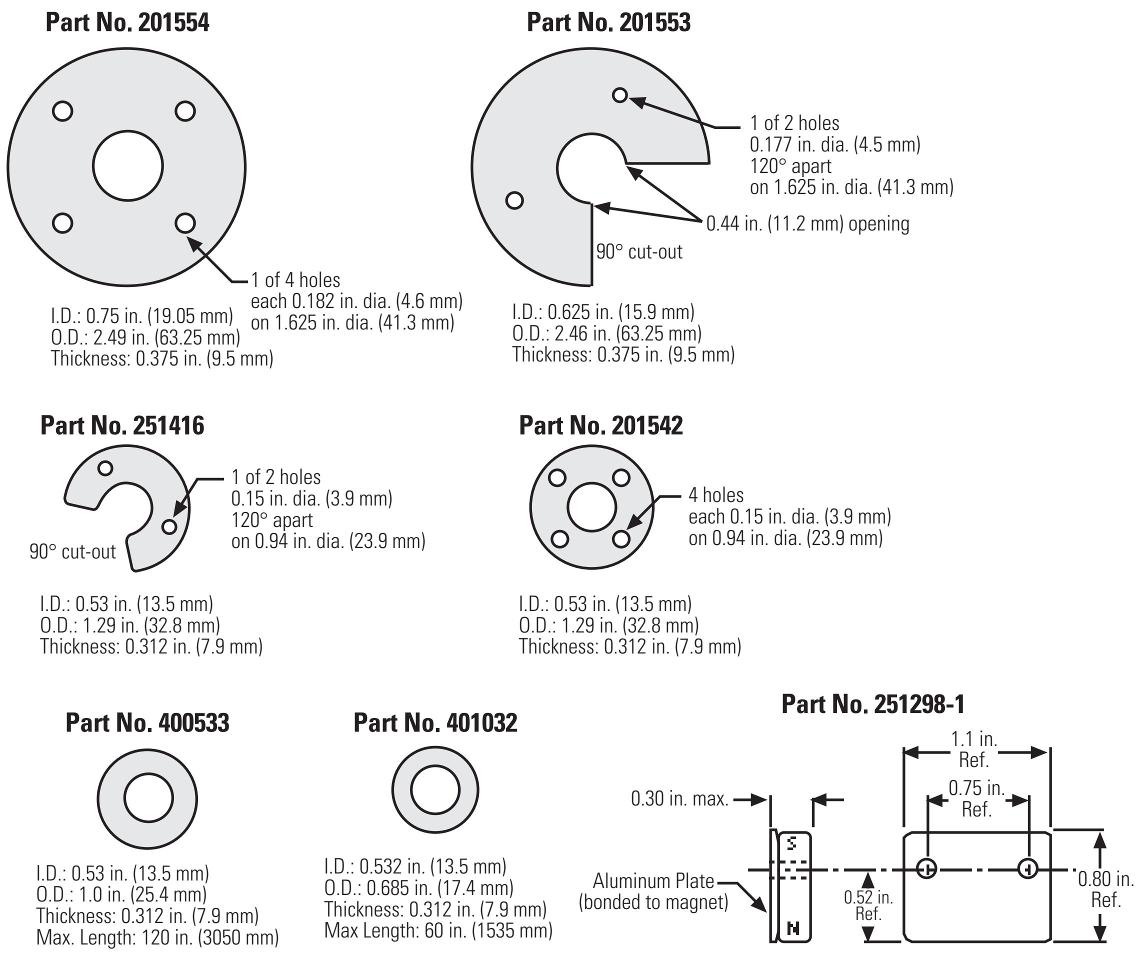


Figure 2-10
Magnet Dimensions

3. Grounding

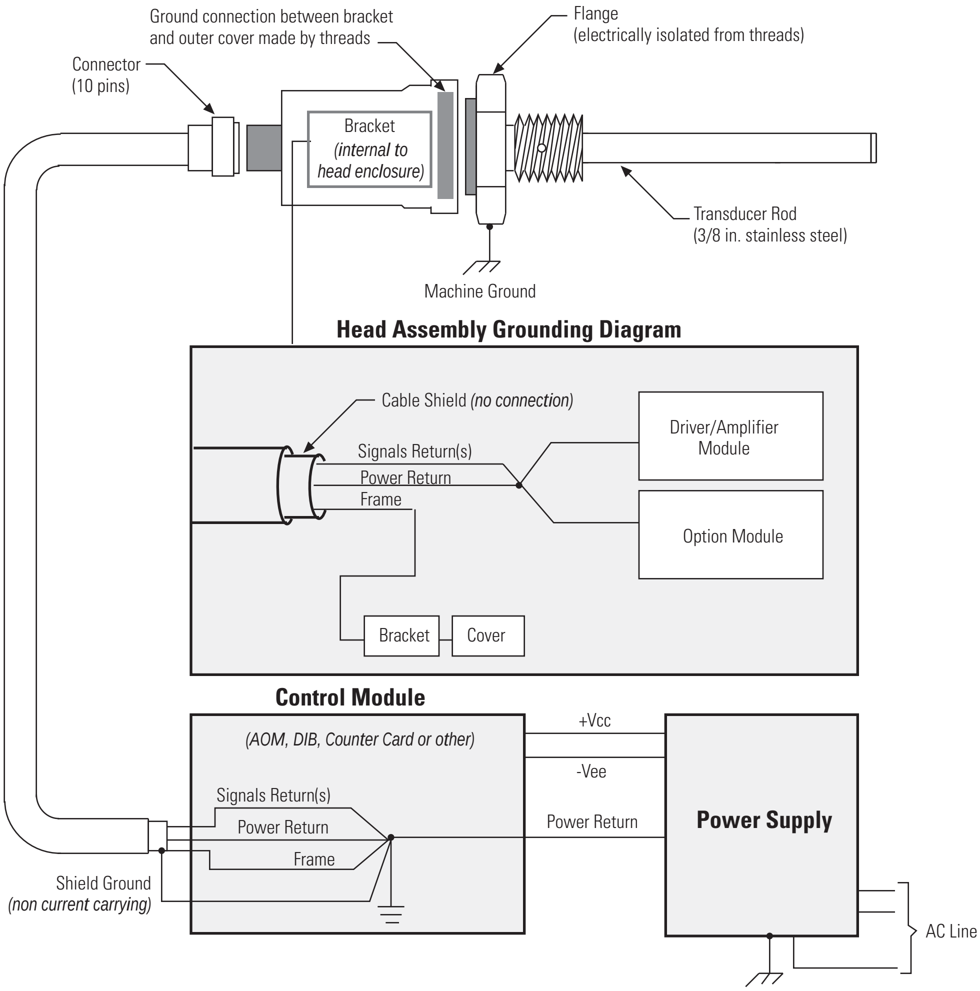


Figure 3-1
Grounding

4. Digital System Configurations

The typical digital system configurations are shown in Figures 4-1, 4-2, and 4-3. Figure 4-1 is a “full” digital system. A full digital system includes a Temposonics II LDT with an integrated Digital Personality Module (DPM) and a Digital Counter Card and supplies either a Binary Coded Decimal (BCD) or Natural Binary output. When ordered as a scaled system, the components are matched and factory calibrated and will provide an exact, discrete resolution.

Figures 4-2 and 4-3 illustrate other system configurations which use the output from either the Digital Personality Module (DPM) or the RS422 Personality Module (RPM) as direct input into a control system. The DPM provides a pulse duration output and the RPM provides an RS422 interface.

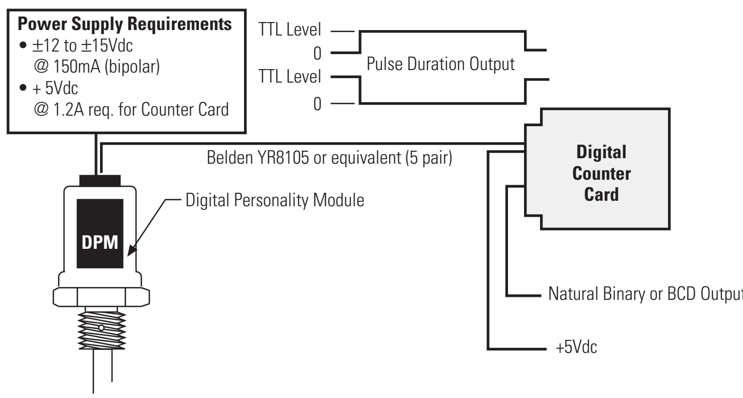


Figure 4-1
Digital System Configuration with DPM, LDT and Digital Counter Card

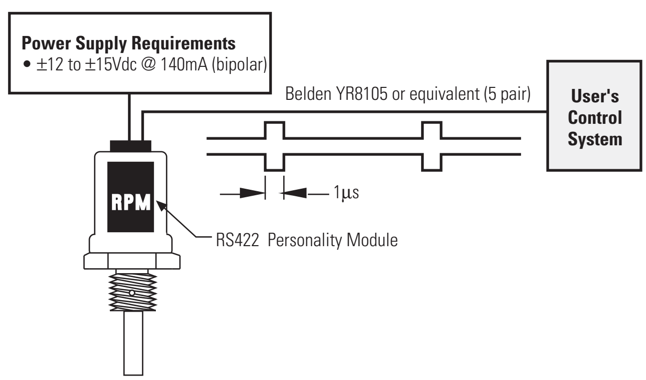


Figure 4-2
Temposonics II Digital System Configuration
with RS422 Personality Module

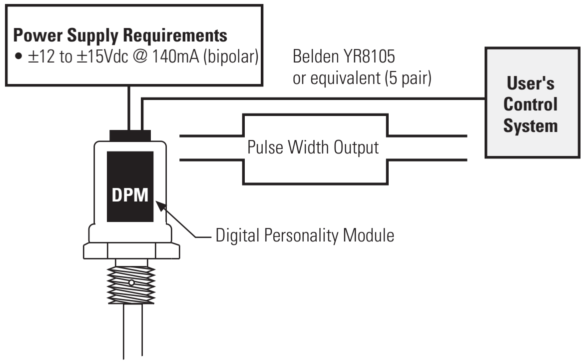


Figure 4-3
Half Digital System Configuration
with an LDT and a DPM

4.1 Specifications/Digital System Components (Temposonics II with TCS Counter Card)

Parameter	*Specification*
Digital Counter Card	
Power Requirements	
Voltage:	+5 Vdc
Current:	800 mA
Output	TTL Compatible, nominal 0 & 5 Vdc, parallel, true high. Source Current: 0.8 A Sink Current: 16 mA (up to 18 bits natural binary, 4 1/4 digit BCD; up to 22 bits binary and 6 digit BCD can be achieved with a second counter card)
Mounting Distance	300 ft. maximum from Digital Personality Module (DPM)
Digital Personality Module	
Recirculations	Selectable from 1 to 127
Interrogation	Internal External (1 to 4μs pulse)
Power Requirements	
Voltage:	± 15 Vdc
Current:	50 mA
Temperature Requirements	
Storage:	- 40°F to 180°F (- 40°C to 83°C)
Operating:	- 40°F to 180°F (- 40°C to 83°C)
RS422 Personality Module	
Interrogation	External
Power Requirements	
Voltage:	± 15 Vdc
Current:	40 mA
Temperature Requirements	
Storage:	- 40°F to 180°F (- 40°C to 83°C)
Operating:	- 40°F to 180°F (- 40°C to 83°C)
Temposonics II Power Supply	
Power Supply Requirements	±15 Vdc at 175 mA maximum, 25 mA minimum [current draw varies with magnet position, maximum draw occurs when the magnet is 2 inches (50.8 mm) from the flange and the minimum update time is being utilized]

4.2 Digital Personality Module (DPM)

The Digital Personality Module (DPM) replaces the functions provided by the digital interface box. The DPM, which is roughly the size of a US postage stamp, is installed directly into the transducer head and provides electronics for pulse shaping, digital recirculations, auto interrogation, and cable interfacing.

> **NOTE:**
> *Call MTS Sensors Division when replacing a Digital Interface Box with an integrated Digital Personality Module (DPM)*

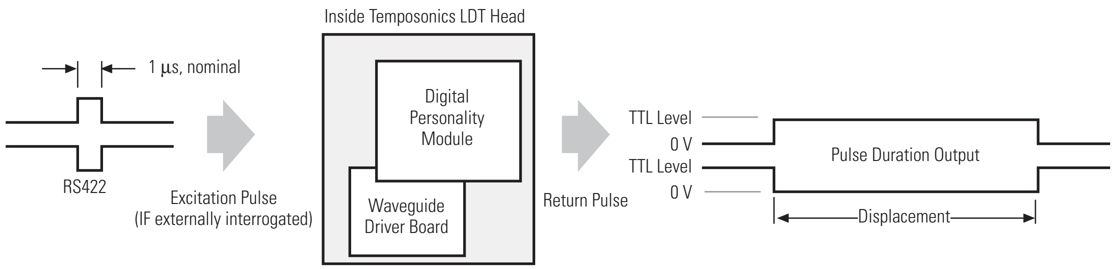


Figure 4-4
Excitation Pulse

The waveguide driver board detects a logic level excitation pulse from the DPM. If the device is externally interrogated, an RS422 excitation pulse is fed from an external control system.

The Temposonics linear displacement measurement systems are available with either synchronous or asynchronous options. These options are available by the configuration of three miniature rotary switches (SW1, SW2 and SW3).

4.2.1 Synchronous (External Interrogating) Mode

In synchronous operation, an interrogation pulse is supplied to the linear displacement transducer from an external counter module. After supplying the pulse, the counter module waits until the recirculation electronics return a termination pulse, and then ends the cycle. The time between the interrogation and termination pulses is proportional to the distance between the transducer head assembly and the movable magnet.

In this synchronous mode, SW1 and SW2 are set to the hexadecimal value of the desired number of recirculations plus 80 (i.e. 81 to FF hex or 129 to 255). SW1 is the least significant digit and SW2 is the most significant digit. Permissible settings are 81 to FF corresponding to 1 to 127 recirculations.

SW3 is ignored in this mode.

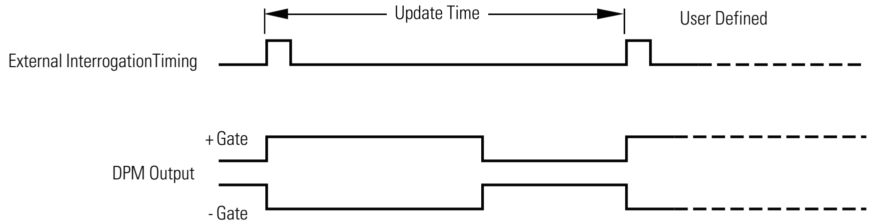


Figure 4-5
Timing for Two Circulations

4.2.2 Asynchronous (Internal Interrogating) Mode

In asynchronous operation the transducer interrogates itself. The DPM uses a fixed interrogation frequency. Switches SW1 and SW2, located on the DPM board, are set to the hexadecimal value of the desired number of recirculations. Permissible settings are 01 to 7F corresponding to 1 to 127 recirculations.

The update rate in this mode is determined by the following formula:

U = (N + 1) * (SW3 + 1) * .2 ms

Where:
U = Update rate in ms
N = # of recirculations selected on SW1 and SW2 (1 to 127)
SW3 = Setting of SW3 (0 to 15)

Refer to the Addendum in the back of this manual for DPM programming procedures.

4.2.3 Operation During Loss of Signal

It is the responsibility of the Digital Counter Card to detect a loss of signal in the system (such as when the magnet is removed from the rod). The DPM supports this mode by supporting a restart mode if the Digital Counter Card negates its interrogation cycle before the end of a data acquisition cycle.

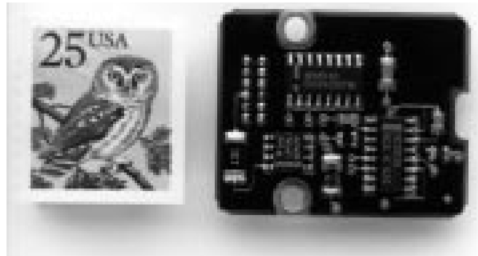


Figure 4-6
RS422 Personality Module (RPM)

4.3 RS422 Personality Module (RPM)

The RS422 Personality Module (RPM) is an alternate integrated circuit module. The RPM is also the size of a US postage stamp and is installed directly into the transducer head to provide the circuitry required to produce an RS422 start/stop output. This signal is then transmitted to a digital counter card or various other devices. The RPM must be interrogated by an external source.

The surface mount components of the RPM reduce moment of inertia and enhance shock and vibration resistance of the module. The simplicity of design makes the module rugged and reliable.

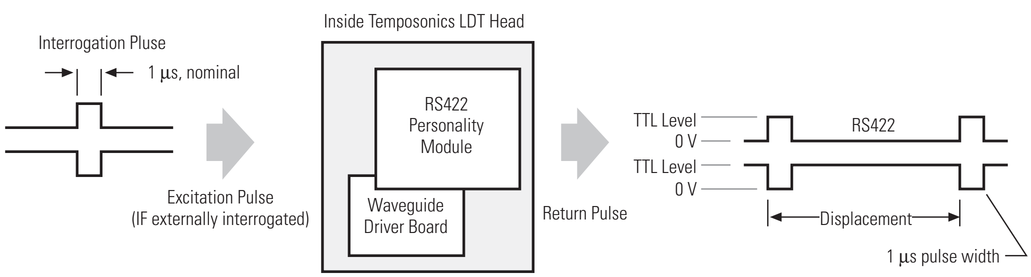


Figure 4-7
The RPM Start/Stop Signal

4.4 Digital Counter Card

The digital counter card measures the on-time of the DPM pulse duration signal. This is accomplished by using a crystal oscillator with frequency selected to provide the desired resolution (counts per inch). A 27-28 MHz crystal is typically used.

The leading edge of the pulse duration signal enables the counter registers, and the trailing edge triggers a “latch pulse” to download the count into the output registers. The latch pulse is normally available for the receiver device to interpret as a “data valid” signal: normally low = data valid, TTL level high = data invalid. The latch pulse frequency is the same as the interrogation frequency, and the duration is nominally 1 microsecond.

Scaling of the counter card is accomplished by matching the counter card crystal frequency to the gradient of the transducer to provide 0.001 inch, 0.0005 inch, etc. per count. Unscaled systems may require scaling within the receiver device, depending upon desired accuracy.

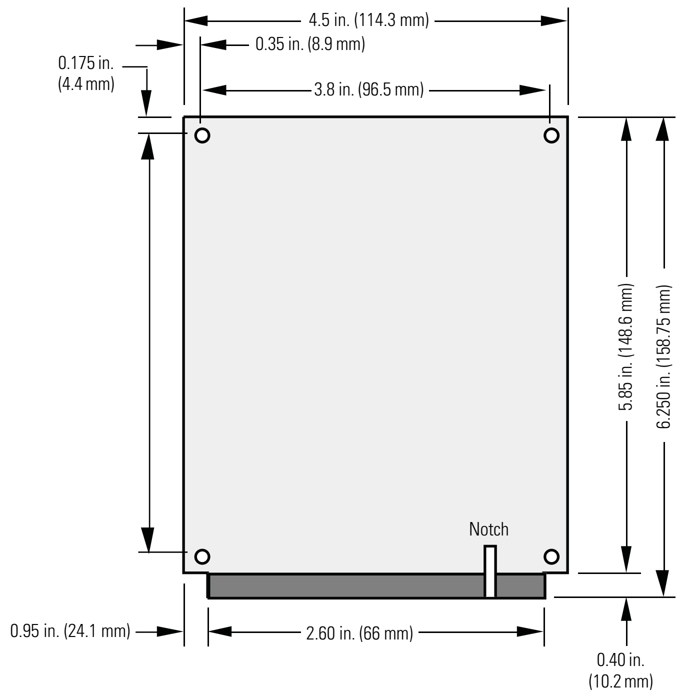


Figure 4-8
TCS Digital Counter Card

4.4.1 Scaling

In most cases, the system supplied is a scaled system. Scaling refers to the selection of system component variables so that the natural binary output represents a discrete number of inches per count, such as 0.002 inch, 0.001 inch, or 0.0005 inch per count. For BCD outputs, scaling means that the output reads directly in inches (mm, etc.), and need not be corrected mathematically.

The system variables that are matched include the transducer stroke, the number of recirculations, the null point, and the counter card crystal oscillator clock. The transducer, DPM, and counter card are factory calibrated to provide the desired resolution. The counter card crystal frequency is calculated based upon the transducer velocity gradient, which is unique to the transducer serial number. The zero is factory set on the counter card, and is also matched to the transducer. To maintain a scaled output, the user should use a transducer and counter card with the same serial number. Substitution of DPMs with the same number of recirculations does not affect the output reading.

An unscaled system is provided upon request. An unscaled system may require calibration to mathematically correct the digital output to read in inches, millimeters, etc. The scale factor for unscaled systems is not a discrete number of inches per count, but should be within 0.2% of the specified resolution for 27-28 MHz systems. For example, an unscaled system specified for 0.001 inches per count may have a scale factor of 0.00002 inches per count (approximately). Similarly, an unscaled BCD output may have a scale factor of 1.002 inches per inch of reading. This does not effect resolution but will vary the counts at any particular point on the stroke. Interchanging system components which do not have the same serial number will also result in an unscaled output.

4.4.2 Spare Parts and Inventory Considerations

The zero can be set on the counter card using DIP switches. An externally interrogated DPM or a counter card can be used as a common spare. However, a system calibration should be performed after any system component change.

5. Digital System Adjustments

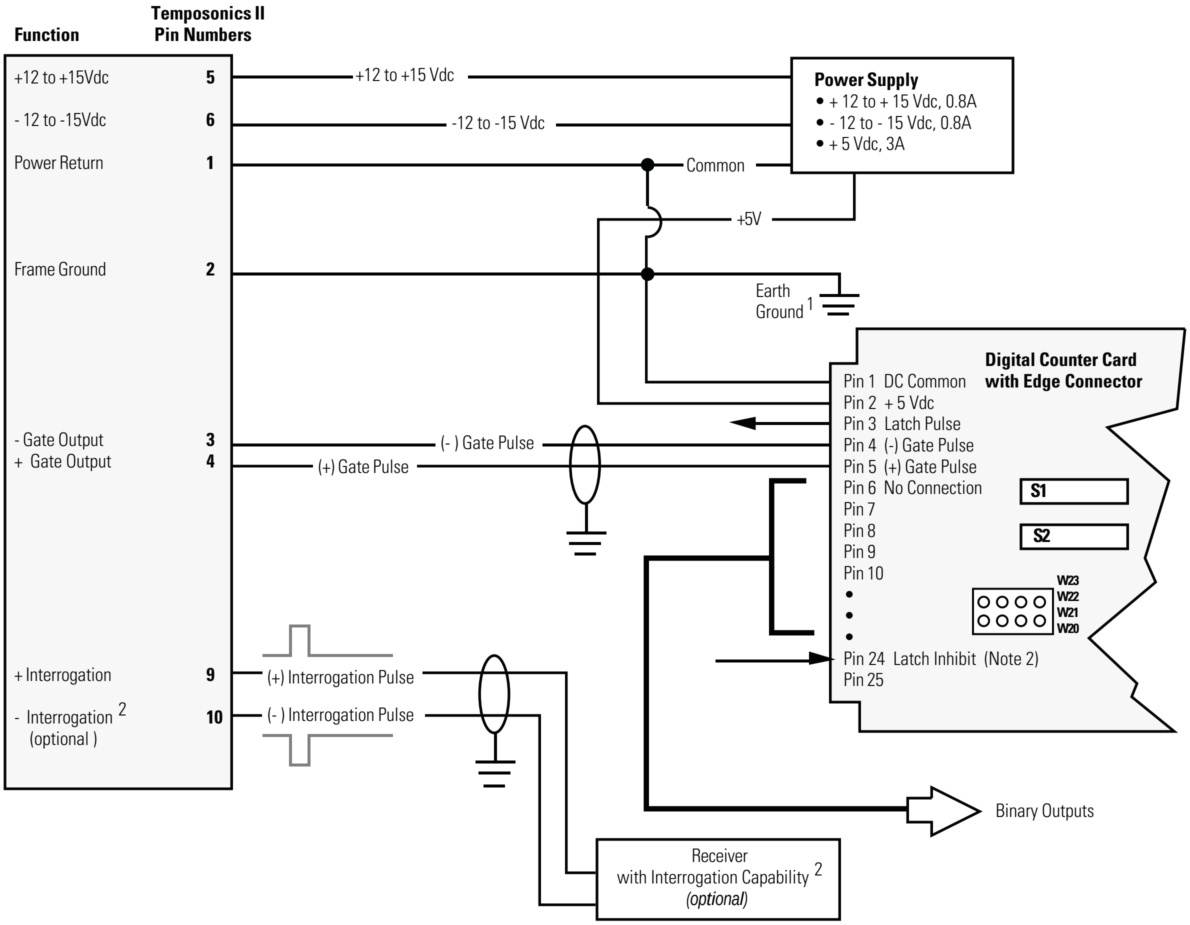
The Temposonics measurement systems do not require service or re-calibration under normal use. The systems' sensing elements are non-contacting and the components are solid state. Performance will not degrade, or drift over time.

Digital systems have a zero-adjustment only. They do not have field adjustments for scale purposes. The output is factory set during final calibration by selection of the counter card crystal frequency and zero-preset. If a system configuration change requires a alternate resolution, the system must be returned to the factory. In some cases, the customer provided receiver device software may be reprogrammed to adjust to the new settings.

6. Electronic Connections

6.1 General

Figure 6-1 (below) illustrates the interconnections of a typical digital system comprised of a Temposonics II transducer, an integrated Digital Personality Module (DPM) and a Digital Counter Card.



NOTES:

1. It is common practice to apply earth ground to power supply common terminals near power supply. Refer to Section 3 for grounding diagram.
2. Jumpers W20 and W22 make Pin 24 inhibit and Pin 3 Latch Pulse
   Jumpers W21 and W23 make Pin 24 Latch Pulse and Pin 3 inhibit.

Figure 6-1
Typical Digital System Connections

To ensure system performance to published specifications, wiring procedures and system configuration guidelines must be carefully followed.

> **NOTE:**
> *The following recommendations are supplied for "full digital" systems, which include a Temposonics Digital Counter Card. For systems which use a digital counting device in the receiver computer, the counter card is not supplied. Use the following procedures in conjunction with the receiver device manufacturer's recommendations.*

6.2 Transducer Connections

The cable from the transducer has 10 conductors (5 pair Belden YR8105 or equivalent). Standard available lengths are 5, 15, and 25 feet. (Consult MTS Sensors Division for custom lengths.) It is recommended to keep the transducer cable as short as possible to avoid possible noise or temperature effects on accuracy.

Table 6A (below) identifies the cable leads from the Temposonics II transducer. Note the three version indicated in the table: Neuter Temposonics II, Temposonics II with an integrated Digital Personality Module (DPM), and a Temposonics II with an integrated RS422 Personality Module (RPM).

Table 6A Temposonics II Transducer Connections

	Temposonics II Integrated or Extension Cable *(see Note 1,2)*		**Temposonics II Configurations:**		• **Neuter:** No Personality Module • **DPM:** Digital Personality Module • **RPM:** RS422 Personality Module
Pin No.	***Color Code*** *(Striped Leads)*	***Color Code*** *(Solid Leads)*	***Neuter***	***DPM Option***	***RPM Option***
1	White/Blue Stripe	White	DC Ground	DC Ground	DC Ground
2	Blue/White Stripe	Brown	Frame	Frame	Frame
3	White/Orange Stripe	Gray	-	(-) Gate	(-) Start/Stop Pulse
4	Orange/White Stripe	Pink	-	(+) Gate	(+) Start/Stop Pulse
5	White/Green Stripe	Red	VCC	VCC	VCC
6	Green/White Stripe	Blue	VEE	VEE	VEE
7	White/Brown Stripe	Black	Not Used	Not Used	Not Used
8	Brown/White Stripe	Violet	Not Used	Not Used	Not Used
9	White/Gray Stripe	Yellow	(+) Interrogation (Note 3)	(+) Interrogation (Notes 4, 5)	(+) Interrogation (Note 5)
10	Gray/White Stripe	Green	(-) Interrogation (Note 3)	(-) Interrogation (Notes 4, 5)	(-) Interrogation (Note 5)

Notes:
1. Verify if the cable has striped or solid color leads and make connections accordingly.
2. Cable : Belden YR8105 or equivalent
3. **IMPORTANT**: Connect the unused interrogation lead to ground.
4. Connect both positive and negative interrogation leads to ground when using a DPM programmed for internal interrogation.
5. When using external interrogation, connect both the positive and negative interrogation leads to provide differential interrogation.

Use Table 6B (below) when:

1. Replacing an original Temposonics transducer (connected to a Digital Interface Box) with a Temposonics II transducer.

2. Replacing an original Temposonics transducer and a Digital Interface Box with a Temposonics II transducer and integrated Digital Personality Module (DPM)

Table 6B Temposonics II Retrofit Wiring Connections

(For direct replacement of Original Temposonics transducer using an existing DIB)

	Temposonics II Cable Color Code (see Note 1,2)			DIB Connections	
Pin No.	***Wire Color (Striped Leads)***	***Wire Color (Solid Leads)***	***Functional Description***	***J2 Pin Connections***	***Retrofit connections to R3 connector*** *(P/N 370160, See Note 7)*
1	White/Blue Stripe	White	DC Ground	J2 Pin B	A
2	Blue/White Stripe	Brown	Frame (Note 3)	J2 Pin B	J
3	White/Orange Stripe	Gray	Not Used	Not Used	K
4	Orange/White Stripe	Pink	Not Used	Not Used	G
5	White/Green Stripe	Red	VCC	J2 Pin F (Pin A if stroke length exceeds 200 in.)	H
6	Green/White Stripe	Blue	VEE	J2 Pin D	B
7	White/Brown Stripe	Black	Amp Return (Gnd.)	J2 Pin B	Not Used
8	Brown/White Stripe	Violet	Amp Output (Return pulse)	J2 Pin C	Not Used
9	White/Gray Stripe	Yellow	+ Interrogation (Note 4, 6)	J2 Pin E	E
10	Gray/White Stripe	Green	- Interrogation (Note 5, 6)	J2 Pin B	D

Notes:

1. Verify if the cable has striped or solid color leads and make connections accordingly.
2. Cable : Belden YR8105 or equivalent
3. Frame ground is isolated from circuit ground inside the transducer head.
4. For retrofitting DIBs with strokes greater than 12 inches (+ interrogation)
5. For retrofitting DIBs with strike lengths less than 12 inches (- interrogation)
6. **IMPORTANT**: Connect the unused interrogation lead to ground.
7. Connections to existing mating connector when replacing a Digital Interface Box with a Temposonics II LDT with a DPM
8. Shield: Connect Extension cable shield at J2 Pin B

Table 6C (below) identifies the cable leads of an original Temposonics transducer.

Table 6C Original Temposonics I Transducer Cable

Signal/Function	***Wire Color Code***
+ 15 Vdc	Green or Gray
DC Ground	Black
Return Pulse from LDT	Orange or Brown
- 15 Vdc	Blue
Interrogation Pulse	White
+ 12 Vdc	Red

Table 6D (below) identifies the terminations to make with the positive and negative interrogation lines (Pin 9 and 10) depending on the Temposonics II configuration being used in your application. It is important note that when using a "neuter" version Temposonics II, DO NOT connect both the positive and negative interrogation leads at the same time — the unused lead must be tied to ground.

Table 6D Temposonics II Interrogation Configurations

Transducer Pin No.	*Functional Description*	*Personality Module Interrogation Mode*
9	(+) Interrogation	Neuter Temposonics II, Temposonics II w/RPM
10	(-) Interrogation	or Temposonics II w/DPM (external interrogation, See Note)
9	(+) Interrogation	Neuter Temposonics II (positive interrogation), Temposonics II w/RPM
10	DC Common	or Temposonics II w/DPM (external positive interrogation)
9	DC Common	Neuter Temposonics II (negative interrogation), Temposonics II w/RPM
10	(-) Interrogation	or Temposonics II w/DPM (external negative interrogation)
9	DC Common	Temposonics II w/DPM (internal interrogation)
10	DC Common	Temposonics II w/APM (all modes)

Note:

1. It is recommended that both the positive and negative interrogation leads be connected when using a Temposonics II with a DPM (external interrogation ONLY). This will provide a differential interrogation signal which is preferred over a single ended interrogation.

6.3 Digital Counter Card Connections

See Appendix A of this manual for an in-depth explanation on how to specify systems with digital output.

Tables 6E, 6F, and 6G show the counter card output connection tables. In order to select the proper table, the following order variables must be known.

Stroke:	_______	inches (mm)
Resolution:	_______	inches (mm)
Recirculation:	_______	(1 - 127)
Output Format:	_______	BCD or Natural Binary
Output:	_______	Latch Pulse (standard: 1µs, optional: 12 µs)
Input:	_______	Latch Inhibit (Standard)

> **NOTE:**
> *The latch pulse is offered on Pin 3 and the latch inhibit is offered on Pin 24, but can be switched via jumpers on the board.*

6.3.1 Latch Pulse

The latch pulse is a nominal 1µs wide pulse that is used as a "data valid" signal. Data is invalid when the signal is high. Data is valid and can be read when the signal is low. The standard latch pulse can be "gated" with a read type pulse generated at the receiver device. The user performs the gating logic external of the counter card. The latch pulse is available on pin 3 of the digital counter card. (An optional 12µs wide latch pulse is available if the 1µs pulse is too fast.)

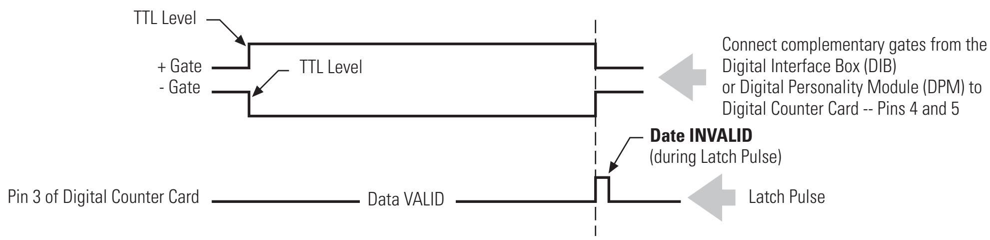


Figure 6-2
Latch Pulse

6.3.2 Protocol

The recommended protocol for assuring that valid count data is received from the counter card is as follows:

- Poll the data-valid output for a logic 1, indicating that data is currently invalid, but will soon be valid.
- Poll the same output for a logic 0, indicating that new, valid count data is present at the outputs of the counter card.
- Bring the latch-inhibit input of the counter card low. This prevents the outputs of the counter card from changing.
- When ready, accept the data into the user control system processing
- After sampling, bring the latch-inhibit input high.

If this protocol is followed, data presented to the user control system from the input module will be valid count data, and the effects of electrical noise and signal transitions will be minimized.

6.3.3 Latch Inhibit Input

The latch inhibit input is available on the digital counter card to "freeze" the binary output signal. The users' receiver provides an inhibit signal to pin 24 on the counter card. The signal must be a low TTL level to inhibit downloading of the updated displacement information into the output registers; the receiver is then provided unchanging data.

6.4 Counter Cards - Natural Binary Output

Table 6E is based upon a counter card with [÷1] divider (factory set). A single card is capable of 18 bits natural binary output maximum.

For the 27-28 MHz crystal, the resulting resolution and recirculations versus stroke are as follows:

Resolution	*Circulations*	*Stroke Length*
0.000125	32	Up to 32 inches
0.00025	16	Up to 65 inches
0.0005	8	Up to 131 inches
0.001	4	Up to 262 inches
0.002	2	Up to 300 inches
0.004	1	Up to 300 inches

Table 6E Counter Card Output (÷1)

Pin No.	Bit Weight	Decimal Value	Bit	Maximum Counts vs. Number of Bits
10	LSB[1]		2^0	1 = 1 bit
9			2^1	3 = 2 bits
8			2^2	7 = 3 bits
7			2^3	15 = 4 bits
14			2^4	31 = 5 bits
13			2^5	63 = 6 bits
12			2^6	127 = 7 bits
11			2^7	255 = 8 bits
18			2^8	511 = 9 bits
17			2^9	1023 = 10 bits
16			2^{10}	2047 = 11 bits
15			2^{11}	4095 = 12 bits
20			2^{12}	8191 = 13 bits
21			2^{13}	16,383 = 14 bits
22			2^{14}	32,767 = 15 bits
19			2^{15}	65,535 = 16 bits
23			2^{16}	131,071 = 17 bits
25	MSB[2]		2^{17}	262,143 = 18 bits

NOTES:
1. LSB = Least Significant Bit
2. MSB = Most Significant Bit. MSB is determined by dividing the stroke length by the resolution and comparing to the maximum count.
For Example: 25 in./0.001 = 25,000; this requires a maximum count of 32,767, thus yielding an MSB at Pin 22.

> **NOTE:**
>
> *When using more than 18 bits Natural Binary or 17 bits BCD, a second counter card is required.*

Table 6F is based upon a counter card with [÷2] divider (factory set). A single card is capable of 17 bits natural binary output maximum.

For the 27-28 MHz crystal, the resulting resolution and recirculations versus stroke are as follows:

Resolution	***Circulations***	***Stroke Length***
0.000125	64	Up to 16 inches
0.00025	32	Up to 32 inches
0.0005	16	Up to 65 inches
0.001	8	Up to 131 inches
0.002	4	Up to 262 inches
0.004	2	Up to 300 inches
0.008	1	Up to 300 inches

Table 6F Counter Card Output (÷2)

Pin No.	Bit Weight	Decimal Value	Bit	Maximum Counts vs. Number of Bits
9	LSB[1]		2^0	1 = 1 bit
8			2^1	3 = 2 bits
7			2^2	7 = 3 bits
14			2^3	15 = 4 bits
13			2^4	31 = 5 bits
12			2^5	63 = 6 bits
11			2^6	127 = 7 bits
18			2^7	255 = 8 bits
17			2^8	511 = 9 bits
16			2^9	1023 = 10 bits
15			2^{10}	2047 = 11 bits
20			2^{11}	4095 = 12 bits
21			2^{12}	8191 = 13 bits
22			2^{13}	16,383 = 14 bits
19			2^{14}	32,767 = 15 bits
23			2^{15}	65,535 = 16 bits
15	MSB[2]		2^{16}	131,071 = 17 bits

NOTES:

1. LSB = Least Significant Bit
2. MSB = Most Significant Bit. MSB is determined by dividing the stroke length by the resolution and comparing to the maximum count. **For Example:** 25 in./0.001 = 25,000; this requires a maximum count of 32,767, thus yielding an MSB at Pin 19.

Table 6G is based upon a counter card with [÷4] divider (factory set). A single card is capable of 16 bits natural binary output maximum.

For the 27-28 MHz crystal, the resulting resolution and recirculations versus stroke are as follows:

Resolution	*Circulations*	*Stroke Length*
0.000125	125	Up to 8 inches
0.00025	64	Up to 16 inches
0.0005	32	Up to 32 inches
0.001	16	Up to 65 inches
0.002	8	Up to 131 inches
0.004	4	Up to 262 inches
0.008	2	Up to 300 inches
0.016	1	Up to 300 inches

Table 6G Counter Card Output (÷4)

Pin No.	Bit Weight	Decimal Value	Bit	Maximum Counts vs. Number of Bits
8	LSB[1]		2^0	1 = 1 bit
7			2^1	3 = 2 bits
14			2^2	7 = 3 bits
13			2^3	15 = 4 bits
12			2^4	31 = 5 bits
11			2^5	63 = 6 bits
18			2^6	127 = 7 bits
17			2^7	255 = 8 bits
16			2^8	511 = 9 bits
15			2^9	1023 = 10 bits
20			2^{10}	2047 = 11 bits
21			2^{11}	4095 = 12 bits
22			2^{12}	8191 = 13 bits
19			2^{13}	16,383 = 14 bits
23			2^{14}	32,767 = 15 bits
15	MSB[2]		2^{15}	65,535 = 16 bits

1. LSB = Least Significant Bit
2. MSB = Most Significant Bit. MSB is determined by dividing the stroke length by the resolution and comparing to the maximum count.
   For Example: 25 in./0.001 = 25,000; this requires a maximum count of 32,767, thus yielding an MSB at Pin 15.

6.5 Counter Card - BCD Output

The Digital Counter Card can be provided with Binary Coded Decimal (BCD) output. BCD code is a binary method of representing decimal numbers. The BCD code for a decimal number is a string of four-bit binary numbers, each of which represents one decimal digit. Only the following binary groups are used:

Decimal No.	Binary No.	Decimal No.	Binary No.
0	0000	5	0101
1	0001	6	0110
2	0010	7	0111
3	0011	8	1000
4	0100	9	1001

For example, the decimal number 8.74 is encoded in BCD as a 12-bit binary number:

Decimal No.	8	7	4	=	8.74
Binary No.	1000	0111	0100	=	1000.01110100

In many cases, the BCD code for a stroke length yields a range of BCD numbers where some bits never change value. For example, 19.999 inches is represented in BCD by the following 20-bit number:

00011001.100110011001

Notice that, for all values from 0 up to 19.999, the first three bits will like- wise be zero. This means that the remaining 17 bits are sufficient to encode a stroke of 19.999 inches; that is, one 18-bit counter card is sufficient.

Table 6H (below) lists the maximum stroke length versus number of significant bits for a resolution of 0.001 inch.

Table 6H BCD Representations of Stroke

X (maximum stroke reading)	BCD Value of 'X'	Required Number of Bits
7.999 (8)	0111 . 1001 1001 1001	15
9.999 (10)	1001 . 1001 1001 1001	16
19.999 (20)	0001 1001 . 1001 1001 1001	17
39.999 (40)	0011 1001 . 1001 1001 1001	18*
79.999 (80)	0111 1001 . 1001 1001 1001	19*
99.999 (100)	1001 1001 . 1001 1001 1001	20*
199.999 (200)	0001 1001 1001 . 1001 1001 1001	21*

** A second Digital Counter Card is required for all values requiring 18 bits or more.*

Table 6I (below) can be used to determine connections for Digital Counter Cards with BCD output.

To determine the applicable connections, you must know the stroke length and resolution. Subtract the resolution from the stroke length to obtain a maximum reading (column 1). Refer to column 7 to determine the decimal equivalent of each digit, knowing the desired decimal position. An example is worked out on the following page.

Table 6I BCD Output Connections

1 Max. Reading	2 No. of Active Bits	3 Active Digits	4 Pin Connectors		5 Binary Weight	6 Digit	7 Check Appropriate Column Resolution			
			Card A	*Card B*						*other*
			8		1	1				
			7		2	(LSD)[1]				
			14		4		0.000	0.001	0.01	
		1	13		8		1			
			12		1	2				
			11		2					
			18		4		0.001	0.01	0.1	
		2	17		8					
			16		1	3				
			15		2					
			20		4		0.01	0.1	1	
999	12	3	21		8					
1999	13	3 1/4	22		1	4				
3999	14	3 1/2	19		2					
7999	15	3 3/4	23		4		0.1	1	10	
9999	16	4	25		8					
19999	17	4 1/4	9[3]	8	1	5				
39999	18	4 1/2		7	2					
79999	19	4 3/4		14	4		1	10	100	
99999	20	5		13	8					
199999	21	5 1/4		12	1	6				
399999	22	5 1/2		11	2	(MSD)[2]				
799999	23	5 3/4		18	4		10	100	1000	
999999	24	6		17	8					

NOTES:

1. LSD = Least Significant Digit
2. MSD = Most Significant Digit
3. Used ONLY with 4 1/4 digits. For 4 1/2 digits or more, a second Digital Counter Card is required (5th digit is on second card).

Example: Stroke = 200 in., Resolution = 0.001 in.

Results:
- Maximum Reading: 199.99 or 200 inches (See column 1)
- Digits: 5 1/4 (1 is considered 1/4 digit)
- Digital Counter Card Connections: Per column 4 (Pin Connections)
- Least Significant Digit (LSD) Connections: Pins 8, 7, 14, 13 (Card A)
- Most Significant Digit (MSD) Connections: Pin 12 (Card B)
  The next MSD connections are Pins 8, 7, 14, 13 on Card B,
  Pin 9 on Card A is NOT USED (see Note 3, below).

Resolution:

1/4 Digit, Pin 12 (Card B): 100
5th Digit: 10
4th Digit: 1
3rd Digit: 0.1
2nd Digit: 0.001
1st Digit: 0.001

Example Table: BCD Output Connection Table

1 Max. Reading	2 No. of Active Bits	3 Active Digits	4 Pin Connectors *Card A*	 *Card B*	5 Binary Weight	6 Digit	7 Check Appropriate Column Resolution			*other*
			8		1	1				
			7		2	(LSD)[1]				
			14		4		0.000	**0.001**	0.01	
		1	13		8					
			12		1	2				
			11		2					
			18		4		0.001	**0.01**	0.1	
		2	17		8					
			16		1	3				
			15		2					
			20		4		0.01	**0.1**	1	
999	12	3	21		8					
1999	13	3 1/4	22		1	4				
3999	14	3 1/2	19		2					
7999	15	3 3/4	23		4		0.1	**1**	10	
9999	16	4	25		8					
19999	17	4 1/4	9[3]	8	1	5				
39999	18	4 1/2		7	2					
79999	19	4 3/4		14	4		1	**10**	100	
99999	20	5		13	8					
199999	21	**5 1/4**		**12**	1	6				
399999	22	5 1/2		11	2	(MSD)[2]				
799999	23	5 3/4		18	4		10	**100**	1000	
999999	24	6		17	8					

NOTES:
1. LSD = Least Significant Digit
2. MSD = Most Significant Digit
3. Used ONLY with 4 1/4 digits. For 4 1/2 digits or more, a second Digital Counter Card is required (5th digit is on second card).

6.6 System Calibration

There are no adjustments on the Digital Personality Module or on the transducer. Instead, the system is calibrated at the Counter Card or by external means. The scaling (inches per count) is determined by a fixed frequency crystal oscillator, while the zero point is determined by re-settable DIP switches on the counter card. Generally, the system components do not show shift, age, or drift over time, and re-calibration is not necessary. However, calibration may be used to compensate for mechanical wear on external mechanical parts connected to the magnet or the transducer.

6.6.1 Re-zeroing the Digital Counter Card

On the Counter Cards, the zero point is preset at the factory, using a pair of DIP switches, S1 and S2. Zero is set at 2 inches from the hex flange of the transducer, or at a distance specified by the customer. If reverse output is specified, the zero point is set at 2.5 inches from the tip of the transducer rod.

There are three ways of changing the zero setting:

1. Mechanical Offset
The zero position can be adjusted by changing the mechanical offset of the magnet relative to the transducer rod. This requires a coupler device which permits a screw adjustment of the magnet.

Fabricate a coupler device to hold the magnet. The coupler should include adjustment screws that allow fine adjustments of the magnet along the transducer rod. Move the magnet to obtain a zero reading.

If the coupler does not allow magnet position adjustment, it can sometimes be used to lock the magnet in place, while shims or washers are used to move the transducer relative to the magnet. (Do not attempt this if the unit is installed in a hydraulic cylinder).

2. Software Programming
In some applications it is possible (and preferable) to maintain a zero offset in software at the receiver. This permits quick re-zeroing without adjusting the magnet or resetting the DIP switches.

For the detailed procedure, consult the manual for the receiver device. Move the magnet to the desired zero position and set the receiver reading to zero.

In most cases, the zero offset is determined by adding the binary complement to the reading observed with the magnet in the desired zero position.

3. Resetting the Counter Card with DIP Switches

For this procedure, the receiver device must be capable of reading each of the Counter Card output bits. For example, the System CRT or LED display may be connected to each bit connection on the input module. If this is not possible, a string of LEDs must be connected to the counter card connector to read each active bit (Refer to Figure 7-1 for a typical connection). Figures 6-5 and 6-6 show DIP switches S1 and S2, along with tables for determining the switch settings.

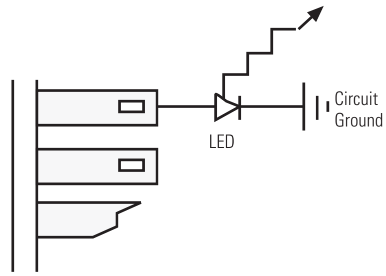


Figure 6-3
Testing Counter Card Output

a. Binary Output

Take the following steps (Refer to Figure 6-4, next page):

1. Before changing any DIP switch positions, record the factory-set positions for reference.

2. Move the magnet to the desired null position. Clamp it in place to prevent movement.

3. Reset all switch segments to the LO (closed) position, taking note of alignment marks on the board.

4. If a PLC or readout device indicates the equivalent counts, write this value in row A of the diagram in Figure 6-4. Then convert this number to binary and write it in row B. To ensure that the count is correct, move the magnet through its stroke and observe the count change. For example, a 24 inch stroke unit with 0.001 resolution should yield a 24,000 count change.

   Alternatively, read each active bit on the counter card output and record into row B of the diagram.

5. Determine the complement of the binary number in row B, by changing 1s to 0s and 0s to 1s. Write this complement in row C.

6. Use the number from row C to mark the columns E and F. If the corresponding bit from C is 1, mark and X in column F (open or HI). If the corresponding bit is 0, mark an X in column E (closed or LO).

7. Turn off power, then set each switch segment to the value (HI or LO) indicated by the Xs in columns E and F.

8. Apply power to the system and check that the output is now zero.

Edge Card Connector

Pin No.																		
Bit	2^{17}	2^{16}	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}
A. Reading in Counts *(If available)*																		
B. Reading in Binary *(From LEDs or Binary of 'A')*																		
C. Complement *(Complement of 'B')*																		

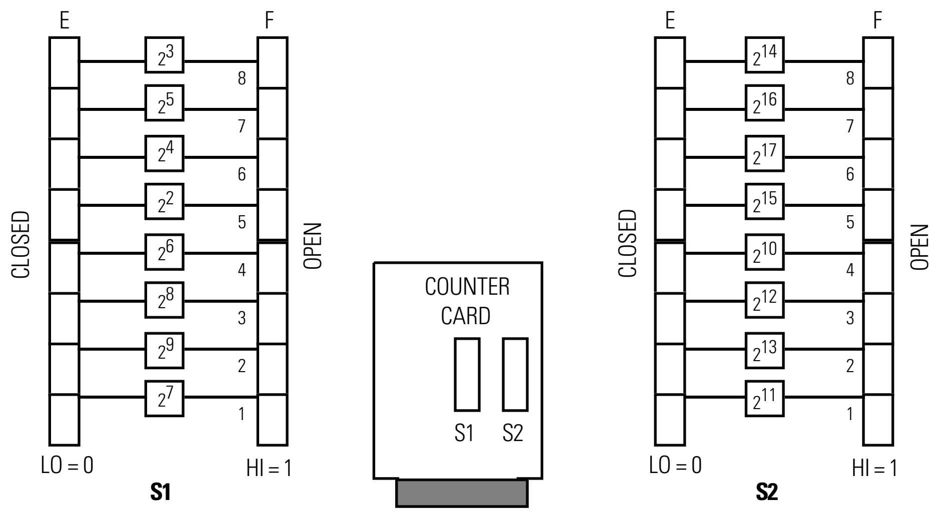


Figure 6-4
Setting DIP Switches (Binary System)

b. BCD Output

Take the following steps (Refer to Figure 6-5, next page):

1. Before changing any DIP switch positions, record the factory-set positions for reference.

2. Move the magnet to the desired null position. Clamp it in place to prevent movement.

3. Reset all switch segments to the LO (closed) position, taking note of alignment marks on the board.

4. If a CRT or other readout device indicates a decimal value (in inches, mm, or other units) convert this value from decimal to BCD binary, and record it in row B of the diagram in Figure 6-5 (next page).

   Alternatively, read each active bit on the counter card output and record this BCD number in row A of the Diagram. Then convert row A to decimal, and record it in row B.

5. Subtract each digit in row B from 9, and record the result in row C.

6. Convert row C into BCD binary and record the result in row D.

7. Use the number from row C to mark the columns E and F. If the corresponding bit from C is 1, mark an X in column F (open or HI). If the corresponding bit is 0, mark an X in column E (closed or LO).

8. Turn off power, then set each switch segment to the value (HI or LO) indicated by the Xs in columns E and F.

9. Apply power to the system and check that the output is now zero.

Edge Card Connector

Digit	10^3				10^2				10^1				10^0				Not Used	
Pin No.	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0		
Bit	25	23	19	22	21	20	15	16	17	18	11	12	13	14	7	8	9	10
A. Reading in BCD *(from LEDs, if used)*																		
B. Reading in Decimal *(From BCD Indicator, if used)*																		
C. Complement *(Subtract B from 9)*																		
D. Converted to BCD *(Convert C to BCD)*																		

If a second Counter Card is provided (required for 5 or 6 digit BCD) use the following table in addition to the table above.

Digit	10^4			
Bit	2^3	2^2	2^1	2^0
Pin No.	13	14	7	8
A. Reading in BCD				
B. Reading in Decimal				
C. Complement				
D. Converted to BCD				

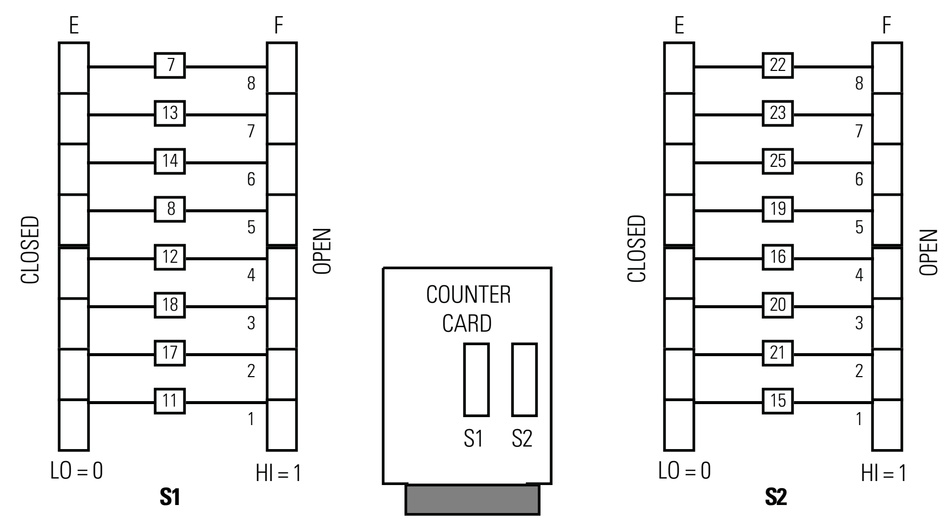


Figure 6-5
Setting DIP Switches (BCD System)

6.6.2 Scaling Digital Counter Cards

1. Scaling is not normally required for digital counter cards because most digital systems are supplied as scaled systems. (Refer to the earlier Subsection 6.4.1, page 18 for a discussion of scaling.)

2. Scaling is required for systems supplied as "unscaled" systems, or if the counter card is not matched to the transducer serial number. Scaled systems will have a discrete scale factor, such as 0.001 inches per count, and do not require scale factor determination.

   To determine the scale factor (or to check system performance), move the magnet to a known measured position on the transducer near full stroke. Observe the output and record it.

   The scale factor is determined by dividing the measurement by the observed number of counts or the observed output in BCD. As an example,

Measurement =	36.000 inches
Reading =	35,420 counts (or 35.420 in BCD)
Scale Factor =	36 = 0.0010163 inches per count (35,420 counts per inch in BCD)

3. For systems that will be used for only one or more discrete positions, move the magnet to the known measured positions that will be repeated during system operation. Observe and record each reading.

   Compare each observed reading to the measured reading and record results. Use the observed readings in software programming as the set point or control points.

   For greater system accuracy, repeat this step and average the readings.

> **NOTE:**
> *To obtain maximum system accuracy perform the above procedures at or near the actual system operating conditions.*

4. For systems that are used for continuous readings or variable set points, apply the scale factor in Step 2 to software programming so that each reading is multiplied by the scale factor (consult receiver device manual). Continue to Step 5.

5. Move the magnet to a known, measured position at or near half of stroke. Observe the reading and compare to the measurement. If the reading varies by more than ±0.05% full stroke, repeat Step 2 using a different measurement near full stroke. Check the new scale factor by performing Step 5 again.

> **NOTE:**
> *To obtain maximum system accuracy, several scale factors should be calculated using different measurements and the factors should be averaged. Readings should be taken at or near actual system operation conditions.*

6. If the readings do not relate to the stroke position, or appear erratic, refer to Appendix D for troubleshooting information.

APPENDIX A How to Specify Systems with Digital Outputs

A.1 General

To order a transducer with digital output, you must first determine the stroke length, the resolution, and the maximum acceptable update time for your application, and then select the appropriate options. Four sizing procedures are provided:

I. Natural Binary Output, using the standard 27-28 MHz clock.
II. Natural Binary Output, using non-standard clocks.
III. BCD Output, using the standard 27-28 MHz clock.
IV. BCD Output, using non-standard clocks.

Note that procedures I and III, based upon a 27-28 MHz counter card clock crystal, offer a scaled output with the standard shipping schedule. If the combinations of options available do not match the resolution or update needs of your application, MTS Sensors Division can (by special order) modify the clock crystal rate to improve resolution or shorten update time. Refer to procedures II and IV to select a non-standard counter card clock crystal.

A.2 Natural Binary Output Selection

PROCEDURE I
System Sizing for Natural Binary Output (Scaled Output, 27-28 MHz Clock Crystal)
This procedure is for 95% of all applications, and provides a scaled output with best possible manufacturing lead time. (For applications requiring a shorter update time or a non-standard resolution, use procedure II.) From the stroke length, resolution, and maximum acceptable update time, we can determined the number of TTL level parallel bits supplied by the Digital Counter Card(s), the number of circulations required in the Digital Personality Module (or Digital Interface Box), and the actual update time using a standard 27 MHz clock crystal.

Take the following steps:

1. Divide the stroke length by the resolution. This number gives the minimum number of counts required. Use Table 1A to determine how many bits are required to accommodate this number.
2. Use Table 2A to determine how many circulations are required for the specified resolution.

> **NOTE:**
>
> *The following additional steps are recommended, to increase output stability:*
>
> *a. Divide the required resolution by 2*
>
> *b. Select the number of bits from Table 1A, using the new resolution.*
>
> *c. Discard or do not connect to the least significant bit.*
>
> *d. Do not exceed 18 bits (to avoid using an additional counter card.)*

3. Use the graph in Figure A-1 to determine the update time, based upon the stroke and circulations.

4. If the update time is unacceptable, adjust the resolution and circulations to lower the update time.

You can make a note of the parameters as you go along:

Number of bits required:	
Resolution (R):	
Circulations (N):	
Update Time:	less than ms.

Table 1A Calculations for Required Binary Bits

Binary Bits	*Maximum Count*	*Maximum Stroke (in.), w/0.001 in. Resolution*	*Maximum Stroke (in.), w/0.0005 in. Resolution*
14	16,383	16	8
15	32,767	32	16
16	65,535	65	32
17	131,071	131	65
18	262,143	262	131
19	524,287	524	262
20	1,048,575	-	-

Table 2A Circulations vs. Resolutions

Resolution	*Circulations (N)*
0.004	1
0.002	2
0.001	4
0.0005	8
0.00025	16
0.000125	32

NOTE:
Values in Table 2A are based on 27-28 MHz clock.

Example 1

Given:

- Stroke: 48 in.
- Resolution: 0.001 in.
- Maximum Update Time: 3 milliseconds

1. 48 ÷ 0.001 = 48000 counts. From Table 1A, this requires 16 bits.
2. From Table A-2, N = 4.
3. The graph (Figure A-1) indicates an update time of approximately 2.3 milliseconds (which is acceptable).
4. Repeat Steps 1 to 3 for half the resolution (0.0005 in.), to provide increased stability for the 0.001 in. least significant bit. Notice that for 0.0005 in. resolution, N = 8 and the update time exceeds the specified maximum of 3 ms. Therefore, specify N=4 and 0.001 inch resolution.

Specify:

Number of bits required: 16

Resolution: 0.001 in.

(Re)circulations: 4
Update Time: less than 3 ms

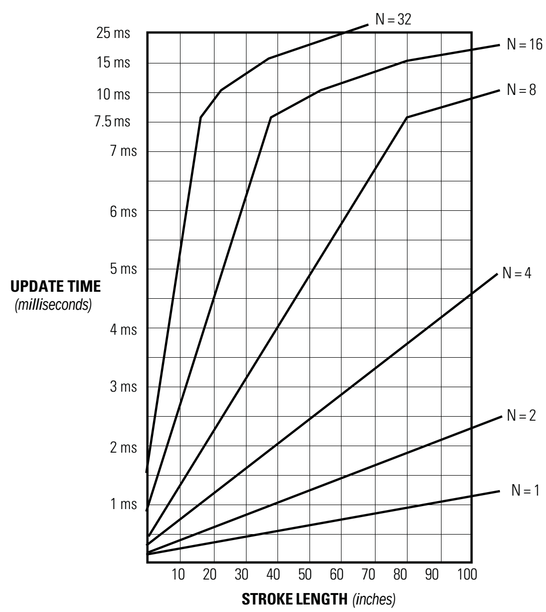


Figure A-1
Update Times (external interrogation)

PROCEDURE II

System Sizing for Natural Binary Output (Special Clock Frequency)

Procedure I above is for 95% of all applications, and provides a scaled output with best possible manufacturing lead time. For applications requiring a shorter update time or a non-standard resolution, use the following procedure to determine an approximate crystal frequency, number of circulations, and update time. Note that systems requiring a special clock frequency can add 2-4 weeks to manufacturing time and slight additional cost.

The crystal frequency versus circulations for a given resolution is approximated by the following formula:

FORMULA:

f_C = (0.11 x D) ÷ [R (inches) x N] *or*

f_C = (2.8 x D) ÷ [R (mm) x N]

where

f_C = Counter Card clock frequency in MHz (maximum 56 MHz)

R = Resolution (inches or millimeters)

N = Number of circulations

D = Counter Card divider (1, 2, or 4 only)

Take the following steps:

1. Divide the stroke length by the resolution. This number gives the minimum number of counts required. Use Table 1A to determine how many bits are required to accommodate this number.

> **NOTE:**
>
> *The following additional steps are preferred, to increase output stability:*
>
> *a. Divide the required resolution by 2*
>
> *b. Select the number of bits from Table 1A, using the new resolution.*
>
> *c. Discard or do not connect to the least significant bit.*
>
> *d. Do not exceed 18 bits (to avoid using an additional counter card.)*

2. Use the above formula to determine the clock frequency, fc, assuming N=1 and D = 1.
3. If the calculated frequency is greater than 40 MHz, divide by N = 2, 4, 8, 16, 32, etc., until you find a value for N which determines an fc between 11 and 40 MHz.
4. Taking the N value from Step 3 and the given stroke, use the graph in Figure A-1 to determine the update time.
5. If the update time is unacceptable, select a lower N value which yields a clock frequency fc of 56 MHz or less. Then recheck the update time.

You can make a note of the parameters as you go along:

Number of bits required: ________

Resolution (R): ________

Circulations (N): ________

Update Time: less than ____ ms.

Example 2

Given

- Stroke: 48 in.
- Resolution: 0.0001 in.
- Maximum Update Time: 30 milliseconds

Specify

Number of bits required: 18
Resolution (R): 0.0001 in.
(Re)circulations: 32
Update Time: less than 25 ms.
fc: 34 MHz

1. 48 ÷ 0.0001 = 480,000 counts. From Table A-1, this requires 19 bits.
2. f_c = 0.11/0.0001 = 1100 MHz
3. Try N = 2, and divide f_c by N: 1100/2 = 550. This is greater than 56 MHz
4. Try N = 4, and divide: 1100/4 = 275. This is also greater than 56 MHz.
5. Try N = 8, 16, and 32. For N = 32, the clock crystal value is 34.4 MHz.
6. The graph in Figure A-1 indicates an update time of less than 25 milliseconds (which is acceptable).
7. Repeat Steps 1-6, using half the resolution, and note that the update time is unacceptable.

Note that this application can also be satisfied in some cases with 0.000125 inch resolution and a standard 27-28 MHz clock crystal.

A.3 BCD Output Selection

Notes on BCD Output

When specified, digital systems can provide BCD (Binary Coded Decimal) output. BCD code is a binary method of representing decimal numbers. In BCD notation, each decimal digit is converted into a four-bit binary number. The BCD code for a decimal number is a string of four-bit binary numbers, each representing one decimal digit. Only the following binary groups are used:

Decimal	Binary	Decimal	Binary
0	000	5	0101
1	0001	6	0110
2	0010	7	0111
3	0011	8	1000
4	0100	9	1001

For example, the decimal number 8.74 is encoded in BCD as a 12-bit binary number:

Decimal	8	.	7	4	=	8.74
BCD	1000	.	0111	0110	=	1000.01110100

In many cases, the BCD code for a stroke length lies within a range of BCD numbers where some bits never change value. For example, 19.999 inches can be represented in BCD by the 20-bit number

00011001.100110011001

Notice that, for all values from 0 up to 19.999, the first three bits will always be zero. This means that the remaining 17 bits are sufficient to encode a stroke of 19.999 inches; that is, one counter card is sufficient. Table 3A lists the maximum stroke length versus number of significant bits (for a resolution of 0.001 inch). By moving the decimal point, the number of bits required for all other resolutions can be determined.

Table 3A

Maximum Stroke Length vs. Number of Significant Bits

X *(maximum stroke reading)*	**BCD Value of 'X'**	**Required Number of Bits**
7.999 (8)	0111 . 1001 1001 1001	15
9.999 (10)	1001 . 1001 1001 1001	16
19.999 (20)	0001 1001 . 1001 1001 1001	17
39.999 (40)	0011 1001 . 1001 1001 1001	18 *
79.999 (80)	0111 1001 . 1001 1001 1001	19 *
99.999 (100)	1001 1001 . 1001 1001 1001	20 *
199.999 (200)	0001 1001 1001 . 1001 1001 1001	21 *

** A second Digital Counter Card is required for all values requiring 18 bits or more.*

PROCEDURE III
System Sizing/BCD Output - "Standard" Resolutions (Using a 27-28 MHz Clock Crystal)

A 27-28 MHz clock crystal can be used to generate 0.001 in. and 0.1 mm resolutions, satisfying the following resolution requirements: 0.1 in., 0.01 in., 0.001 in, 1 mm, and 0.1 mm. For other resolutions, use procedure IV.

Take the following steps to determine the number of bits, circulations, update time, and counter card divider:

1. Select the circulation number N from Table 4A, using the calculated values. Begin by using the values in the first column (for counter card divider D = 2).

Table 4A

Recirculation Values for Selected Resolution

Resolution (R)	**Recirculations (N)** *D = 2*	*D = 1*	*Remarks*
0.1 in.	N/A	N/A	Use 0.001 in. resolution and discard the two least significant digits.
0.01 in.	N/A	N/A	Use 0.001 in. resolution and discard the least significant digit.
0.001 in.	8	4	
1 mm	N/A	N/A	Use 0.1 mm resolution and discard the least significant digit.
0.1 mm	2	1	

2. Using the N value selected, look up the update time in the graph, Figure A-1. If this update time is acceptable, record the values for N, R, D, and update time, and go on to Step 3. If this update time is not acceptable, try Step 1 again, using the values for D = 1. The divider D = 2 is preferred, to prevent instability of the least significant digit (LSD). If one or more digits are discarded, however, D = 2 offers only marginal improvement over D = 1.
3. Use Table 3A to determine the number of BCD bits required to generate the given resolution.

NOTE:

If the number of bits required is 18 or more (requiring two counter cards), and the desired resolution is 0.1 inch, 0.01 inch, or 1 mm, then consider the alternate procedure in Section IV.

You can make a note of the parameters as you go along:

Number of bits required:		
Resolution (R):		
Circulations (N):		
Update Time:	less than	ms.

PROCEDURE IV
System Sizing for BCD Output - Other Resolutions/Non-Standard Clock Crystal

For 0.1 in., 0.0001 in., 0.01 mm, and 0.001 mm, a non-standard counter card clock crystal must be estimated using the following procedure.

> **NOTE:**
> *Procedure IV should be used only when absolutely necessary. Ordering a non-standard clock crystal will add approximately four weeks to normal manufacturing lead times. An additional nominal charge also applies. Procedure III above should be used whenever possible.*

The crystal frequency for a given resolution versus circulations is approximated by the following formula.

FORMULA:

$$f_c = (0.11 \times D) \div [R\,(\text{inches}) \times N]$$

or

$$f_c = (2.8 \times D) \div [R\,(\text{mm}) \times N]$$

where

f_c = Counter Card clock frequency in MHz
R = Resolution (inches or millimeters)
N = Number of circulations
D = Counter Card divider (1, 2, or 4 only)

Take the following steps:

1. Select an N (circulation) value using Table 5A for the resolutions shown. These pre-calculated values are normally sufficient. As an alternative, N values can be calculated using the formulas above. Begin by using the values from the first column (for counter card divider D = 4). If none are available under D = 4, then use values from the next column (D = 2).
2. Using the N selected, look up the update time in the graph, Figure A-1. If this update time is acceptable, record the values for N, R, D, and update time, and go on to Step 3. If this update time is not acceptable, use the formula above to calculate values for N and try Step 1 again, using the values for D = 2, then, if necessary, D = 1. The higher divider numbers are preferred, to prevent instability of the least significant digit (LSD). If one or more digits are discarded, however, D = 2 offers only marginal improvement over D = 1.
3. Use Table 3A to determine the number of BCD bits required to generate the given resolution.

Table 5A
Recirculation Values for Resolutions

Resolution (R)	**Recirculations (N)**		
	D = 2	*D = 1*	*Remarks*
0.1 in.	N/A	N/A	Use 0.001 in. resolution and discard the two least significant digits.
0.01 in.	N/A	N/A	Use 0.001 in. resolution and discard the least significant digit.
0.001 in.	8	4	
1 mm	N/A	N/A	Use 0.1 mm resolution and discard the least significant digit.
0.1 mm	2	1	

You can make a note of the parameters as you go along:

Number of bits required:

Resolution (R):

Circulations (N):

Update Time: less than ms.

NOTE:

DPM programming switches are pre-set at the factory. Only authorized OEMs are permitted to program this device. Call MTS before making any adjustments to the switches.

REMOVING THE TRANSDUCER COVER VOIDS THE WARRANTY.

WARNING!

The DPM is a static sensitive device and should be treated as such. MTS recommends that a static wrist strop be worn during installation and programming. Also, these procedures are to be conducted in a clean (dust and moisture-free) environment.

A small flat head screwdriver should be used to program the switches. See Figure B-1 for switch locations.

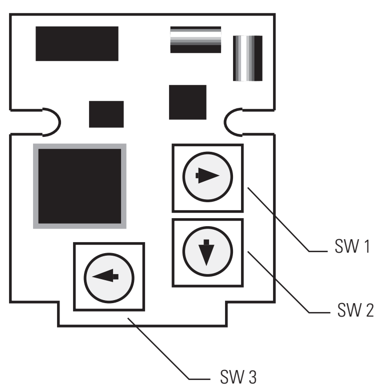


Figure B-1
DPM Switch Locations

B.1 Setting Number of Recirculations

SW1 and SW2 are programming switches that are used to set the number of recirculations (1 through 127). Refer to Table 2B (next page).

NOTE:

The number of recirculations are specified by the customer at time of order. This number is based on resolution and frequency. You can use Table 1B to choose the number of recirculations based on resolution using a 27 - 28 MHz crystal.

Hexadecimal numbers 01 to 7F (for internal interrogation) and 81 to FF (for external interrogation) are printed on the switches. Choose the desired number of recirculations from Table 2B and set SW1 and SW2 to the corresponding hexadecimal numbers.

Table 1B
Resolution vs. Recirculations

Resolution	Recirculation
0.004	1
0.002	2
0.001	4
0.0005	8
0.00025	16
0.000125	32

Values are calculated using a 27-28 MHz Crystal.

Table 2B
Recirculation Switch Settings

Internal Interrogation		Recirculations	External Interrogation	
SW 2	*SW 1*		*SW 2*	*SW 1*
0	1	**1**	8	1
0	2	**2**	8	2
0	4	**4**	8	4
0	8	**8**	8	8
1	0	**16**	9	0
2	0	**32**	A	0
4	0	**64**	C	0
7	F	**127**	F	F

B.2 Setting Update Time (Internal Interrogation)

SW3 is the programming switch that is used to set the update time for internal interrogation.

NOTE:

SW2 disables SW3 in external interrogation. That is, setting SW2 to any hexadecimal number past 7 will disable SW3. SW3 is pre-programmed for external interrogation from the factory.

Update time is programmed with SW3 using hexadecimal numbers 0 - F. Refer to Table 3B (next page). To find the minimum required update time (Umin) use the following procedure:

FORMULA #1:

U(min) = (2.5 + NULL + STROKE) x .01086 ms/in. x N

where

NULL = Null length in inches
STROKE = Stroke length in inches (1 to 300 inches)
N = Number of recirculations

1) Select from Table 3B the switch setting for SW3 that yields the closest update time greater or equal to Umin.
2) Verify the exact update time of the transducer with the following formula:

FORMULA #2:

U = (N + 1) x (SW3 + 1) x 0.2 ms

where

N = Number of recirculations
SW3 = Switch setting in decimal

B.3 Example:

Given

- Null = 2 in.
- Stroke Length = 20 in.
- Resolution = 0.001 in.

Solution

1) From Table 1B, the corresponding resolution to number of recirculations is N = 4.
2) The ***minimum*** required update time using Formula #1 (previous page) is:

   Umin. = (2.5 + 2 + 20) x .01086 x 4 = 1.064 ms

3) Table 3B shows that the closest update time greater or equal to Umin corresponding to N = 4 is 2.00 ms; therefore, SW3 = 1.
4) The exact update time using Formula #2 (previous page) is:

   U = (4 + 1) x (1 + 1) x .2 ms = 2 ms

Table 3B

SW 3 Setting Update Time as a Function of Stroke and Recirculation

(Internal Interrogation Only)

Recirculations	**SW3 Setting (according to stroke length in inches)**								
	1-32	*32.1-65*	*65.1-102*	*102.1-135*	*135.1-175*	*175.1-215*	*215.1-250*	*250.1-290*	*290.1-300*
1	0	1	2	3	4	5	6	7	8
2	1	2	3	5	6	7	9	A	B
4	1	3	4	6	7	9	B	C	E
8	1	3	5	6	8	A	C	E	F
16	1	3	5	7	9	B	D	F	F
32	1	3	5	7	9	B	E	F	F
64	1	3	5	7	9	B	D	F	F
127	1	3	5	7	9	B	D	F	F

APPENDIX C Modifications to the Digital Interface Box

C.1 Modifying the Polarity of the Interrogation Pulse

Consult drawings 650110 and 250068 before performing the following procedure.

From INTERNAL to EXTERNAL interrogation

1. Remove the 4 cover screws from the DIB.
2. Remove cover with PCB connected. Turn component side up with J1 to the left and J2 to the right as you face the board.
3. Remove the 555 timer from the bottom of the 16-pin DIP socket (position U1B— Pins 1-4 and 13-16).
4. Install a 9637 IC* on the top side of the same 16-pin DIP socket (position U1 Pins 5-8 and 9-12).
5. Install a 100Ω resistor between Pins D and E of J1 10-pin connector (or E1 and E2).

From EXTERNAL to INTERNAL Interrogation

1. Remove the 4 cover screws from the DIB.
2. Remove cover with PCB connected. Turn component side up with J1 to the left and J2 to the right as you face the board.
3. Remove the 9637 IC from the top side of the 16-pin DIP socket (position U1B Pins 5-8 and 9-12).
4. Install a 555 timer** on the bottom side of the same 16-pin DIP socket (position U1 Pins 1-4 and 13-16).
5. Install the proper value resistor (or next highest available value) in R1 location. Use the following formula to determine the resistor value:

   R1 (KΩ) - [T(msec) x 14.43] - 1
6. Install R2 (499Ω), C1 (0.1μF) and C13 (0.01μF) if R1 is not present.

C.2 Changing Recirculations

1. Remove the 4 cover screws on the DIB.
2. Locate the jumper wire in the center of the PCB attached to “0” and some other number ranging from 1 to 8. There are 8 possible points.
3. Use the chart below to change from 0 to X to get N (number of desired (re)circulations).
4. Install U3 (74161) for recirculations above 8.

Jumper (From 0 to X)	**N** (No. of circulations)
0 to 1	**1**
0 to 2	**2**
0 to 3	**4**
0 to 4	**8**
0 to 5	**16**
0 to 6	**32**
0 to 7	**64**
0 to 8	**128**

NOTE:

Any DIB having a high number of circulations can be changed to a lower number without having an effect on the interrogation pulse timing.

C.3 Changing Polarity of Interrogation Signal

This procedure is used when connecting a negative pulse transducer to a positive pulse DIB, or when connecting a positive pulse transducer to a negative pulse DIB.

> **NOTE:**
>
> *The only transducers with a negative interrogation pulse are original Temposonics I transducers with stroke lengths of 12 inches or less (the serial number indicated on the transducer label ends with "N" to denote a negative interrogation pulse).*
>
> ***Temposonics II transducers can provide either a positive or a negative interrogation pulse.*** *The positive pulse is available on Pin 9 of the transducer connector (white/gray stripe or yellow wire of pigtail connection). The negative interrogation pulse is available on Pin 10 of the transducer connector (gray/white stripe or green wire of pigtail connection).*

1. Remove the 4 cover screws on the DIB.
2. Remove cover with PCB connected. Turn component side up with J1 to the left and J2 to the right as you face the board.
3. Make one connection to Pin-E on the J2, 6-pin connector, which represents the positive (+) or negative (-) pulse.

Example:

- Post E14 to J2 Pin-E is (+) polarity
- Post E13 to J2 Pin-E is (-) polarity

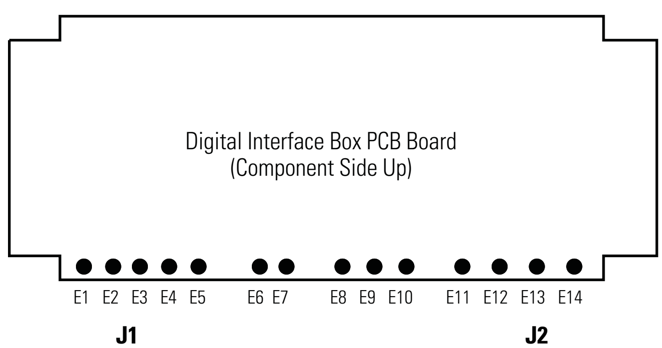


Figure C-1
Digital Interface Box - Posts E1 - E14

APPENDIX D Troubleshooting

This section consists of troubleshooting procedures to be used when operational problems are encountered.

> **NOTE:**
> *The following procedures are for general troubleshooting purposes. Purchase of replacement components should not be determined solely upon results of these tests. Consult MTS Sensors Division for recommendations before purchasing replacement system components.*

D.1 General

If the output signal is erratic or unchanging, turn off power and recheck mechanical and electrical installation. Once all steps have been checked, continue with diagnostic test procedures to determine the cause of fault. The possible causes of faulty output are listed below in order of probability of occurrence, and should be checked in order.

1. Improper power supply/power connection

2. Mismatched system components*

3. Ground loops/improper grounding*

4. Improper wiring for counter card connections*

5. Incorrect receiver device or software*

6. Improper magnet mounting*

7. EMI noise, affecting transducer, transducer cable, or counter card cable*

8. Circuit fault within transducer

9. Circuit fault within counter card

** Will cause erratic or unstable output*

The equipment required for diagnostic testing is:

1. Analog or digital voltmeter
2. Circuit tester or ohmmeter
3. Oscilloscope, 50 MHz (15 MHz minimum) — dual channel preferred

IMPORTANT NOTE:

This procedure is for checking the power supply voltage to the Digital Interface Box (DIB). The DIB is a discontinued product, but this procedure is included in this manuals to support prior installations.

This procedure will determine if the power supply rating is sufficient, or if there is a voltage drop occurring in the field wiring.

Perform the following procedure to check power supply voltage and connections at the interface box.

1. Remove power and disconnect J-1 10 pin connector from the Digital Interface Box (DIB). Also remove edge connector from counter card. Turn power on and check open circuit voltages at the connector pins of the Digital Interface Box' mating connector.

2. Pin H should read +15 Vdc with respect to Pin A.
   Pin B should read -15 Vdc with respect to Pin A.
   Pin C should read +5 Vdc with respect to Pin A.

3. Check power supply voltages under load by connecting a 150 ohm resistor (or similar 1.5 watt, 12-15 Vdc load*) between pins H and A and read the voltage across the resistor. The value should be 14.25 Vdc minimum.

4. Connect a 220 ohm resistor (or similar 1 watt, 12-15 Vdc load*) between pins B and A and read the voltage across the resistor. The value should be -14.25 Vdc minimum.

5. Connect a 10 to 12 ohm resistor (or similar 2 watt, 5-6 Vdc load*) between pins A and B and read the voltage across the resistor. The voltage should read +4.75 Vdc minimum.

Perform the following procedure to check the power supply voltage and connections at the 5 volt power supply.

1. Connect a 4 ohm, 5 watt resistor (or similar 1.2 amp load* across the +5 Vdc terminals of the power supply. The voltage should be +4.75 Vdc minimum.

2. Reconnect the counter card and digital interface box. Read the voltage at the counter card edge connector, pin 2 with respect to pin 1. The voltage should read +4.75 Vdc minimum.

** Automotive 12 or 6 Vdc bulbs of the proper wattage are acceptable alternatives.*

D.3 Temposonics II Digital System Signals

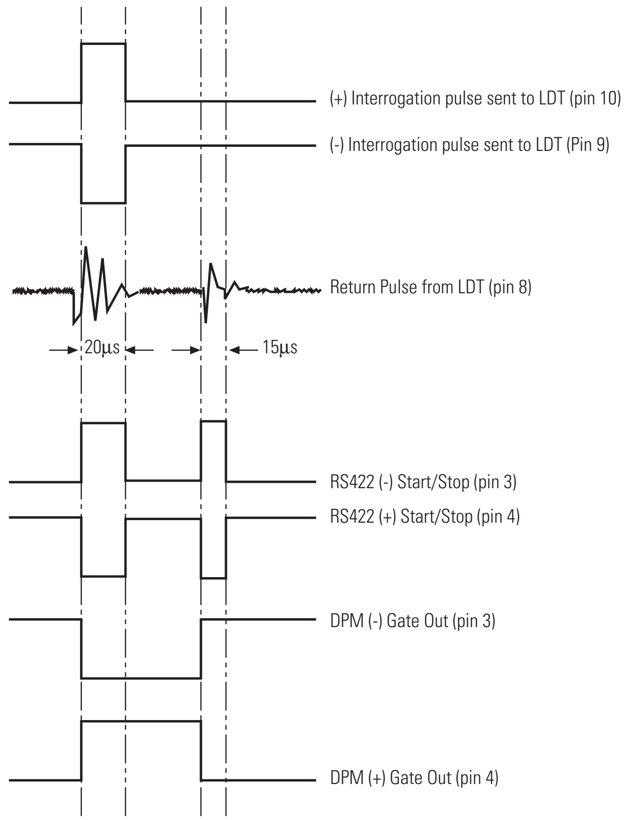


Figure D-1
Digital System signals

D.4 Wiring Check

Improper wiring can cause either an erratic output or complete loss of output signal. The following instructions should be followed to check all connections.

1. Disconnect or remove DC power to the system.

2. Trace all wiring from the counter card to the transducer. Ensure that maximum cable length and type is observed.

3. Check system grounds. Figure D-3 shows a typical circuit diagram with the required and optional grounds. Ensure that circuit ground is made at only one location to avoid ground loops. If erratic or unstable output is encountered, recheck all earth grounds and cable grounds.

4. Disconnect transducer from the DIB while the power is off.

5. Connect the J1 connector to the DIB and restore power.

6. Check for the voltages listed below on the J2 (6-pin) connector on the DIB with respect to J2, pin-B (Ground).
   A = +12 to +15 Vdc
   D = -13 to -15 Vdc
   F = +11.5 to +12 Vdc

7. Connect an oscilloscope to J2 pin-E with respect to J2 pin-B to see the 1µs, TTL, interrogation pulse (see Figure D-4). Transducers with stroke lengths ≤ 12 inches should have a negative signal and transducers with stroke lengths 13 inches or longer will have a positive signal.

8. Disconnect power and connect transducer back to the DIB and look for the same voltage and signal levels as in step 6 and 7 with the power restored.

9. Connect the oscilloscope to J2 pin-C with respect to J2 pin-B to see the transient return pulse along with the recirculations (see Figure D-5). If these signals are not present, go to the next step.

10. Disconnect power and isolate J2 pin-C (return pulse) from the DIB. Connect the oscilloscope to pin-C on the transducer side and restore the power. The signals should look like Figure D-5. If not, send the transducer to MTS Sensors for repair.

D.5 Counter Card Digital Output Test Procedure

The Counter Card output, (14-18 bits typical), is a true high TTL level signal nominal 0 to 5 volts DC. The receiver device must be selected to interface with the TTL level signal of the Counter Card. Most devices offer a TTL input option or a specific model selection designed for TTL only. If the user suspects an improperly selected or malfunctioning receiver device, the Counter Card output may be tested using LEDs.

Perform the following procedure:

1. Disconnect the receiver device from the binary output of the Counter Card. This is usually performed at the receiver device input terminals.

2. Connect 4 or more LEDs (rated for 3-5 Vdc, 50 mA maximum) between the binary output and power supply ground as shown in Figure 9-1. Select the bits (or digit) which will give a reading which is easily interpreted. (Four of the “middle” bits for natural binary; tenths or units place for BCD). The LEDs light when the bit is high. (Note that output voltage will drop under load - refer to a TTL data book for details.)

3. With the above test set-up procedure, some of the LEDs should light immediately. If no LEDs light, move the magnet through the stroke of the transducer and ensure that one or more LEDs light. If none respond, recheck the wiring of the LEDs and the power supply connections to the Digital Counter Card (Pins 1 and 2).

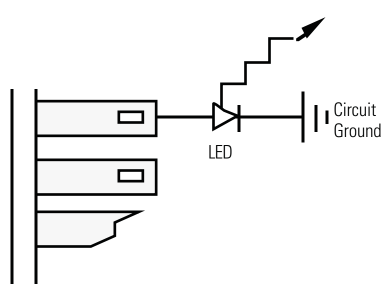


Figure D-2
Testing Counter Card Output

4. To check the Counter Card reading, move the magnet between two measured positions on the stroke, and record the LED readings, as “HI” or “LO”. Take the complement of the readings, and calculate the decimal equivalent of the readings. Refer to Table 1D (next page).

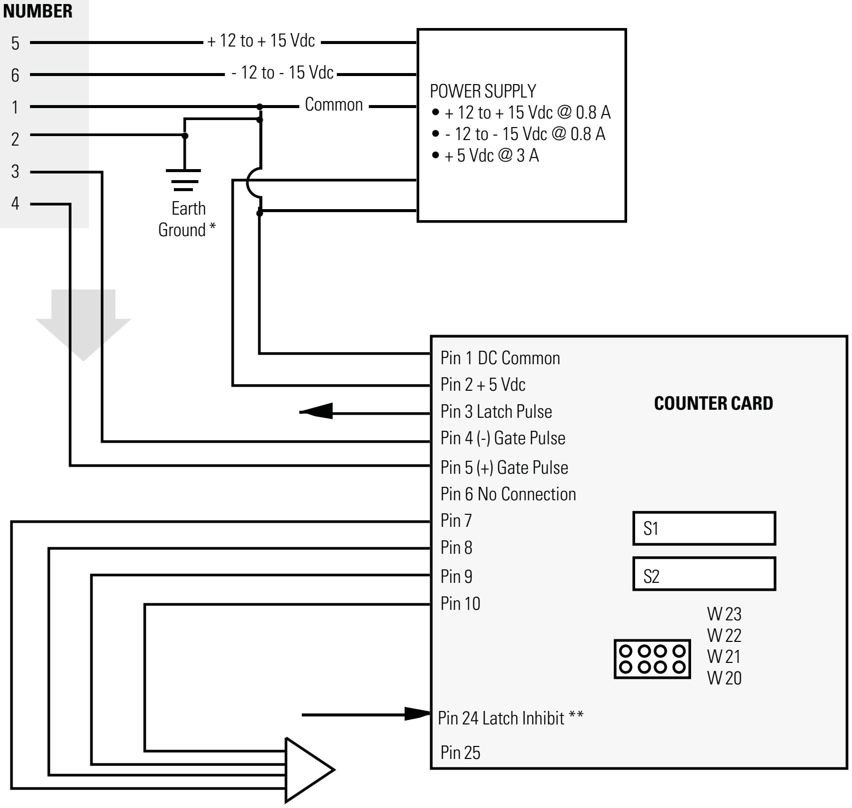
Table 1D LED Test

Bit Number	LED	Complement (A)	Decimal Weight (B)	A x B
2^0			0.001	
2^9	HI = 1	LO = 0	0.512	0
2^{10}	LO = 0	HI = 1	1.024	1.024
2^{11}	HI = 1	LO = 0	2.048	0
2^{12}	LO = 0	HI = 1	4.096	4.096
		Sum =	5.120	(inches of stroke)

Repeat the procedure for position 2, and compare the inches of stroke measured to the inches of stroke observed. A change in reading between 2 points on the stroke is a general indication of proper system operation.

Temposonics II Transducer Connections

FUNCTION	WIRE COLOR	PIN NUMBER
Vcc	White/Green Stripe	5
Vee	Green/White Stripe	6
Common	White/Blue Stripe	1
Frame Ground	Blue/White Stripe	2
- Gate Output	White/Orange Stripe	3
+ Gate Output	Orange/White Stripe	4



NOTES:

* It is common practice to apply earth ground to power supply terminals near power supply.

** Jumpers W 20 and W 22 make P1 Pin 24 inhibit and P1 Pin 3 latch pulse
Jumpers W 21 and W 23 make P1 Pin 24 latch pulse and P1 Pin 3 inhibit.

Figure D-3
Signal and Power Wiring, Digital Systems

IMPORTANT NOTE:

The MTS Customer Service Department should be consulted before attempting any repairs in the field. Failure to consult MTS will void the warranty.

D.5 Digital Interface Box (DIB)

1. Turn power OFF.

2. Disconnect transducer from DIB.

3. Turn power ON.

4. Check the following voltages on Pin-B (Gnd.) on J2 (6-pin) of the DIB.
   Pin A = +12 to +15 Vdc
   Pin D = -13.5 to -15 Vdc
   Pin F = +11.5 to +12 Vdc

3. If any voltage is missing or is not within specification, send the DIB to the factory for repair. If voltages are correct go to Step 4.

4. With power on, use an oscilloscope to check the interrogation signal to the transducer on J2 Pin-E on the DIB. If no signal is present, send the box to the factory for repair. If the signal looks like the example below, go to step 5.

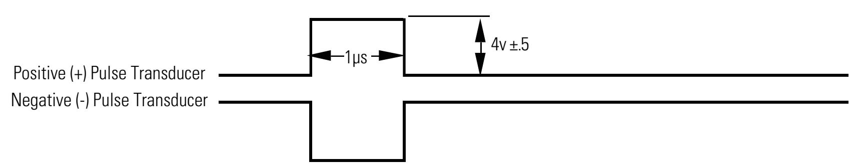


Figure D-4
Interrogation Signal

5. Connect oscilloscope to Pin-C on the transducer cable. The return pulse and recirculations should be present. Go to Step 6 if these signals are present. Return the DIB to the factory for repair if the signals are not present. Below is an example of a DIB with 4 recirculations.
   Volts/div: 1v
   Time/div: 5µs (delay mode)

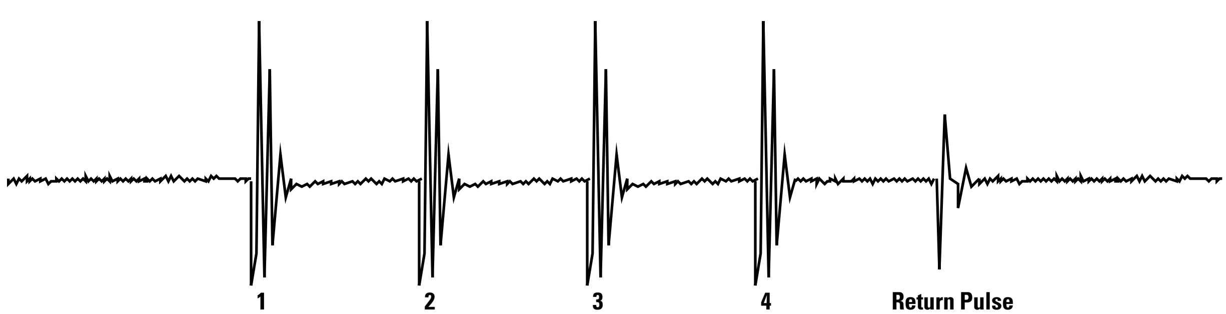


Figure D-4
(4) Recirculation Pulses

6. Observe the gate signals on Pins G(+) and K(-) on the J1 connector. A complimentary TTL level output (0 volts low, 5 volt high) should be present. Return the DIB to the factory for repair if gate signals are not present.

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550409 C

INSTALLING AN ANALOG PERSONALITY MODULE (APM)

CAUTION!

The APM is a static sensitive device and should be treated as such. MTS recommends a static wrist wrap be worn during installation and that these procedures are conducted in a clean environment.

1. Place the transducer hex in a vise.

2. Unscrew the cover using hand pressure only. Note that cover has right-hand threads. A specially designed cover wrench is available from MTS.

CAUTION!

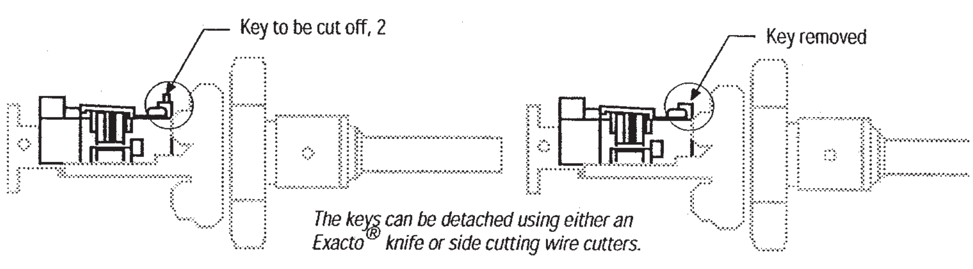
Hands must be clean. Ensure that no foreign material contacts the inside components.

To assure full coverage under warranty and error-free future replication orders, install this label as instructed in Step 9.

3. Once the cover is removed, clean the inner threads of the cover and bracket with a lint free cloth. Spray ONLY the cover threads with Sherwin Williams number 00217 Teflon® spray.

4. Remove APM from the static sensitive bag by holding the module by its edges, being careful that the plastic does not contact the transducer mechanism. The old coil block design has a key that can interfere with a new APM. If an APM is being installed on a transducer with the old coil block design, be sure to cut off the key before installing the new APM as indicated in the drawing below. Refer to the programming procedures on the next page if the APM needs to be reprogrammed.

Figure 1



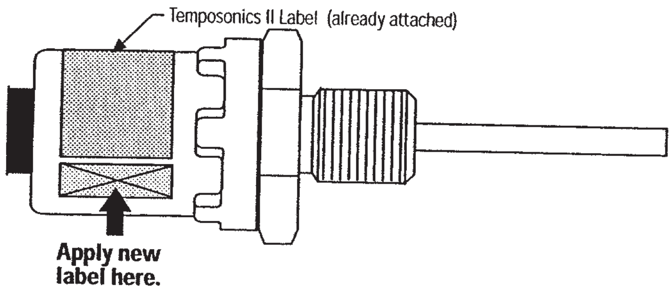
5. Align the 12-pin connector on the interconnect board with the socket on the APM, ensure the pins are straight, and press gently until the module is securely inserted.

6. Once the module is inserted, secure the APM with hardware provided until they are snug. DO NOT OVER TIGHTEN!

8. Carefully align the cover to the threads and hand tighten until snug against the gasket.
   DO NOT OVER TIGHTEN COVER.

9. Once cover is secure, attach the label provided as shown in Figure 2.

Figure 2



10. Connect transducer and verify proper operation.

APM PROGRAMMING PROCEDURE

CAUTION!

IMPORTANT: Before beginning the programming procedures, supply power to the APM for a full 5 minutes. This will allow all components to stabilize and ensure set point accuracy.

The output range of the APM is determined by choosing two endpoints within the active stroke length of the transducer and using the two push-buttons to assign a voltage to each point. The two endpoints are called Set Point 1 (SP1) and Set Point 2 (SP2). Any voltage from -10 volts to +10 volts may be assigned to either point; the APM will automatically scale the output to the specified range. Set point 1 must be the set point closest to the head electronics.

In addition, the APM can be programmed for one of the three performance modes. During the programming procedure, each mode is represented by a particular output voltage. The three modes are as follows:

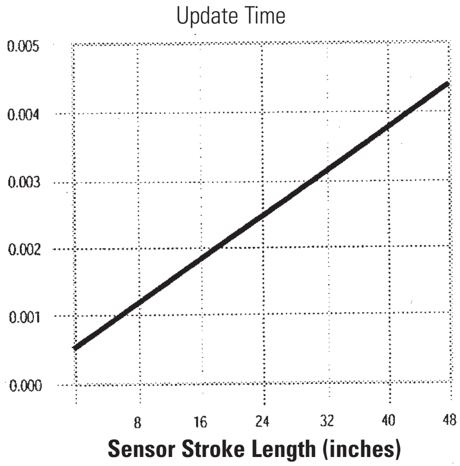
Resolution Preferred Mode:
In this mode the APM generates a high resolution output while sacrificing update time. The Resolution Preferred Mode is limited to stroke lengths up to 48 inches and will provide an output resolution of approximately 0.001 inches. In applications exceeding 48 inches, the APM must be set for Balanced Mode or Update Preferred Mode. In the programming procedure, the Resolution Preferred Mode is indicated by an output of 0 volts.

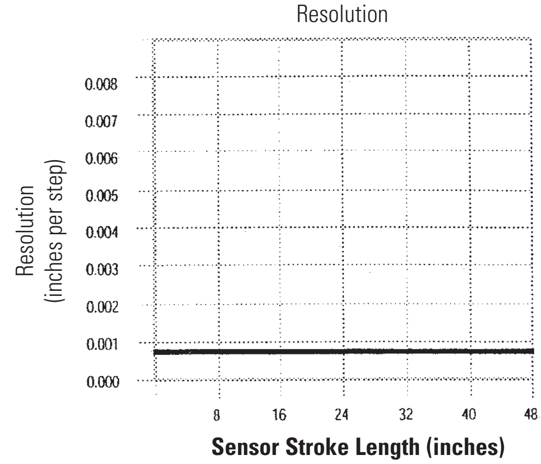
Balanced Mode:
In this mode the APM offers a “balance” between update time and resolution. For stroke lengths up to 250 inches, the output resolution will be approximately 0.003 inches. In the programming procedure, this mode is indicated by an output of +10 volts.

Updated Preferred Mode:
In this mode the APM produces the fasts possible update time while sacrificing resolution. For stroke lengths up to 300 inches, the output resolution will be approximately 0.007 inches. In the programming procedure, this mode is indicated by an output of -10 volts.

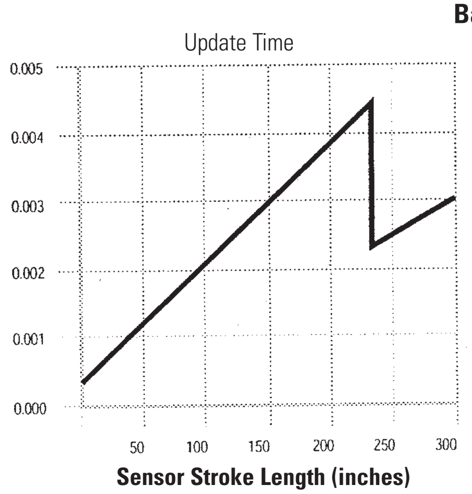
The following charts identify the Update Time versus the Resolution for stroke lengths up to 300 inches for each of the three mode selections.

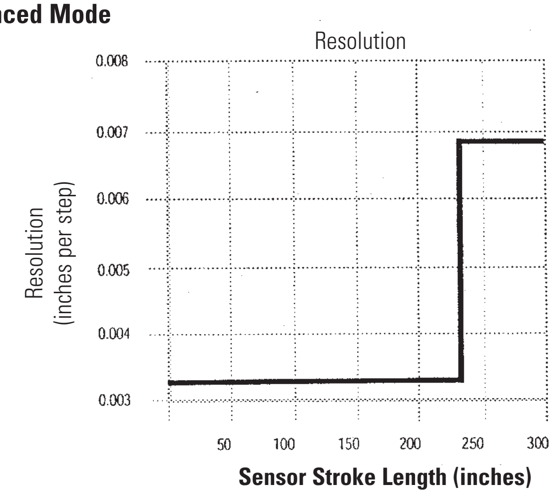
Resolution Preferred Mode



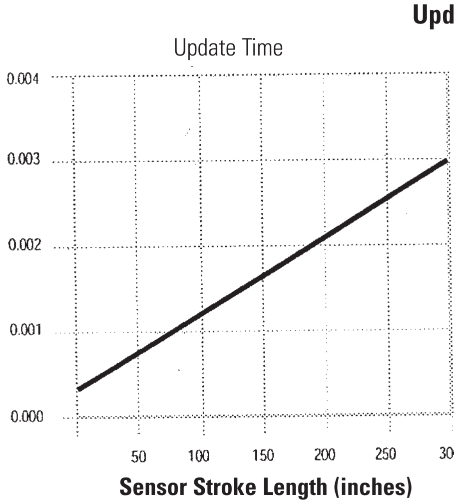


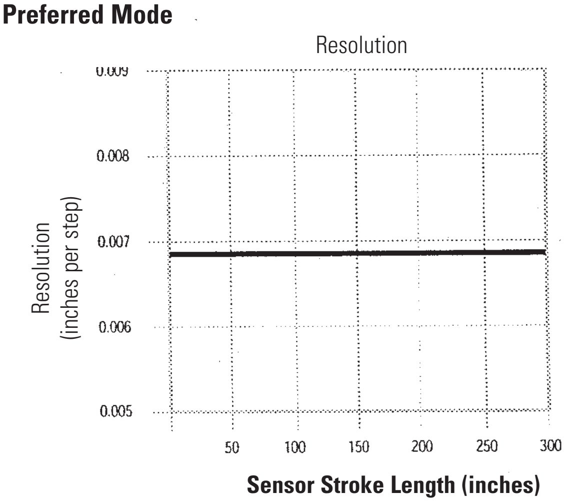
Balanced Mode





Updated Preferred Mode





It is necessary to monitor the analog output with a digital volt meter while performing the following steps.

1. Move the permanent magnet to the desired position for Set Point 1. Press the SP1 push-button until the APM enters the programming mode (3 seconds) and acknowledges by producing an output voltage of about +5 volts. Release the SP1 button.

2. Press and release the SP2 button to enter the performance-mode setup mode. The APM will acknowledge by producing an output voltage which corresponds to the currently stored performance mode (see below). If the APM has never been programmed, the default mode will be resolution preferred (that is, the output voltage will be 0 volts).

   - Resolution Preferred Mode = 0 volts
   - Balanced Mode = +10 volts
   - Updated Preffered Mode = -10 volts

3. At this point, repeated presses of the SP2 button will cause the APM to cycle through the three performance modes. Continue to press and release the SP2 button until the voltage output indicates the voltage associated with the correct mode for your application. Once the correct voltage is displayed, press and release the SP1 button to accept the mode setting. The APM acknowledges by producing an output voltage of a approximately -5 volts.

4. Press and release the SP1 button to enter the Set Point 1 setup mode. The APM will acknowledge by producing an output voltage of about -2.5 volts.

5. At this point, you can use the SP1 and SP2 buttons to choose the voltage to assign to Set Point 1. Pressing and holding the SP1 button causes the output voltage to move in the positive direction; pressing and holding the SP2 button causes the output voltage to move in the negative direction. If either button is held for more than five seconds, the output volatge will begin to change more quickly. Release the button when the desired output voltage is displayed on the digital volt meter. (For testing purposes, it is not necessary to perform this step. It can be skipped entirely since it only assigns the final voltage to the Set Point.).

6. To complete the setup for Set Point 1, press and release both buttons simultaneously. If the transducer has been previously programmed, it will resume operation with the new voltage assigned to SP1. If it has not been previously programmed, it will return to the same voltage it had prior to entering the pro gramming mode (near 0 volts).

7. Move the permanent magnet to the desired position for Set Point 2. Press the SP1 push-button until the APM enters the programming mode (3 seconds) and acknowledges by producing an output voltage of approximately +5 volts. Release the SP1 button.

8. Press and release the SP2 button to enter the performance-mode setup mode. The APM will acknowledge by producing an output voltage which corresponds to the currently stored performance mode. If the APM has never been programmed, the default mode will be resolution preferred (that is, the output voltage will be 0 volts).

9. At this point, repeated presses of the SP2 button will cause the APM to cycle through the three performance modes. Continue to press and release the SP2 button until the voltage output indicates the voltage associated with the correct mode for your application. Once the correct voltage is displayed, press and release the SP1 button to accept the mode setting. The APM acknowledges by producing an output voltage of approximately -5 volts. (Note that the mode chosen in this step should be the same as the one chosen in step 3. If a different mode is chosen, it will overwrite the one chosen previously.)

10. Press and release the SP2 button to enter the Set Point 2 setup mode. The APM will acknowledge by producing an output voltage of +2.5 volts.

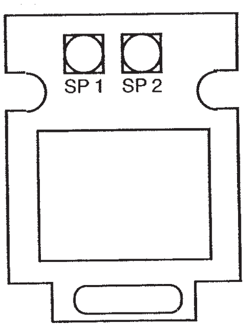
11. At this point, you can use the SP1 and SP2 buttons to choose the voltage to assign to Set Point 2. Pressing and holding the SP1 button causes the output voltage to move in the positive direction; pressing and holding the SP2 button causes the output voltage to move in the negative direction. If either button is held for more then five seconds, the output voltage will begin to change more quickly. Release the button when the desired output voltage is displayed on the digital volt meter. (For testing purposes, this step may be skipped completely.).

12. To complete the setup for Set Point 2, press and release both buttons simultaneously. If the transducer was previously programmed, it will resume operation with the new voltage assigned to Set Point 2.

CAUTION!

If the APM is being programmed for the first time, the analog output at power-up will be near zero volts. The programming steps are the same in this case, but the analog output will return to zero volts until valid information is stored for both Set Point 1 and Set Point 2. When both Set Points have been programmed, the transducer will enter normal operating mode and produce an analog output scaled according to the information permanently stored in APM's memory.

Figure 3
APM, Top View



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DIGITAL PERSONALITY MODULE

Installing an Digital Personality Module (DPM)

! CAUTION !
The DPM is a static sensitive device and should be treated as such. MTS recommends a static wrist wrap be worn during installation and that these procedures are conducted in a clean environment.

ATTENTION:
Attach an updated label to this document before shipment to customer

To assure full coverage under warranty and error-free future replication orders, install this label as instructed in Step 9.

1. Place the transducer hex in a vise.

2. Unscrew the cover using hand pressure only. Note that cover has right hand threads. A specially designed cover wrench is available from MTS.

! CAUTION !
Hands must be clean. Ensure that no foreign material contacts the inside components.

3. Once the cover is removed, clean the inner threads of the cover and bracket with a lint free cloth. Spray ONLY the cover threads with Sherwin Williams #00217 Teflon® spray.

4. Remove DPM from the static sensitive bag by holding the module by its edges, being careful that the plastic does not contact the transducer mechanism. The old coil block design has a key that can interfere with a new DPM (if a DPM is being installed on a transducer with the old coil block design, be sure to cut off the key before installing the new DPM as indicated in the drawing below. Refer to the programming procedures on the next page if the DPM needs to be reprogrammed.

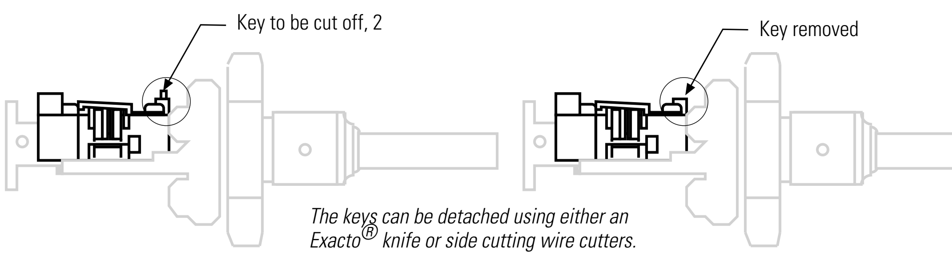

Figure 1

5. Place provided insulator on the bracket.

6. Align the 12 pin connector on the interconnect board with the socket on the RPM, ensure pins are straight, and press gently until PM is securely inserted.

7. Once the module is inserted, secure with the 2 provided Plastite screws until snug. DO NOT OVER-TIGHTEN!

8. Carefully align the cover to the threads and hand tighten until snug against the gasket.

9. Once cover is secure, attach the provided label as shown in Figure 2.

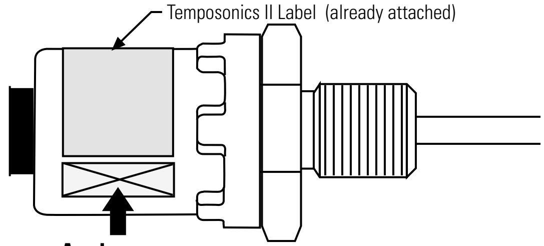

Figure 2

10. Connect transducer and verify proper operation.

DPM Programming Procedure (Asynchronous Mode)

NOTE

DPM programming switches are set from the factory. Call MTS before making any adjustments to the switches. A small flat head screw driver should be used to program the switches. (See Figure 1, next page, for switch locations).

! CAUTION !

The DPM is a static sensitive device and should be treated as such. MTS recommends a static wrist wrap be worn during installation and programming. These procedures are to be conducted in a clean environment.

1. SW1 and SW2 are programming switches used to set the number of recirculations from hexadecimal numbers 01 to 7F or from 81 to FF (refer to Table 2). Table 1 indicates the resolutions that are attainable with a given number of recirculations; these numbers assume a standard 27 to 28 MHz crystal is being used.

2. SW3 is the switch used to program, or set, the update time for internal interrogation. Update Time is programmed using hexadecimal numbers 0 to F (refer to Table 3). Follow the steps below to program Update Time.

Step A: Knowing the stroke length, the null, and the resolution desired, use Table 1 to find the corresponding number of recirculation required.

Step B: Find the minimum required update time (Umin) using the formula below:

U(min) = (2.5 + Null + Stroke) (.01086 ms/in. x N)

Where:

Stroke = stroke length in inches (1 to 300 inches)

N = number of recirculations

Null = null length in inches

Step C: Go to Table 3 to select the switch setting SW3 that yields the closest update time which is greater than or equal to Umin.
Step D: Use the following formula to verify the exact update time of the transducer.

Update Time = (N + 1) (SW3 + 1) (0.2 ms)

Where:

N = number of recirculations

SW3 = switch setting in decimal

EXAMPLE: *Given:*

Stroke Length = 20 inches

Null = 2 inches

Resolution = .001 inch

SOLUTION: a. From Table 1, the corresponding recirculation is N = 4.

b. From Step B, above, the minimum required update time is:

Umin = (2.5 + 2 + 20) (.01086) (4) = 1.064 ms

c. The programming table shows that the closest update time greater than or equal to Umin corresponding to N = 4 is 2.00 ms; and SW3 = 1.

d. Verifying the update time, from Step 2, the exact update time is:

Update Time = (4 + 1) (1 + 1) (0.2 ms) = 2 ms

Switch Settings

Table 1

Resolution vs. Recirculations w/27-28 MHz Crystal

Resolution	*Recirculation*
0.004	1
0.002	2
0.001	4
0.0005	8
0.00025	16
0.000125	32

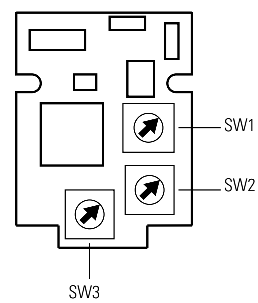

Figure 3

Switch Locations

Table 2

Recirculation Switch Settings

Internal Interrogation			*External Interrogation*	
SW 2	SW 1	*Recirculation*	SW 2	SW 1
0	1	1	8	1
0	2	2	8	2
0	4	4	8	4
0	8	8	8	8
1	0	16	9	0
2	0	32	A	0
4	0	64	C	0
7	F	127	F	F

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Fax: 919-677-0200

SW2	SW1	N	SW3	U		U		U		U		U		U		U	SW3	U
0	**1**	**1**	**0**	**0.40**	**1**	**0.80**	**2**	**1.20**	**3**	**1.60**	**4**	**2.00**	**5**	**2.40**	**6**	**2.80**	**7**	**3.20**
0	**2**	**2**	**0**	**0.60**	**1**	**1.20**	**2**	**1.80**	**3**	**2.40**	**4**	**3.00**	**5**	**3.60**	**6**	**4.20**	**7**	**4.80**
0	3	3	0	0.80	1	1.60	2	2.40	3	3.20	4	4.00	5	4.80	6	5.60	7	6.40
0	**4**	**4**	**0**	1.00	**1**	**2.00**	**2**	**3.00**	**3**	**4.00**	**4**	**5.00**	**5**	**6.00**	**6**	**7.00**	**7**	**8.00**
0	**...**	**...**																
0	**8**	**8**	**0**	**1.80**	**1**	**3.60**	**2**	**5.40**	**3**	**7.20**	**4**	**9.00**	**5**	**10.80**	**6**	**12.60**	**7**	**14.40**
0	...	...																
0	F	15	0	3.20	1	6.40	2	9.60	3	12.80	4	16.00	5	19.20	6	22.40	7	25.60
1	**0**	**16**	**0**	**3.40**	**1**	**6.80**	**2**	**10.20**	**3**	**13.60**	**4**	**17.00**	**5**	**20.40**	**6**	**23.80**	**7**	**27.20**
1	...	...																
1	F	31	0	6.40	1	12.80	2	19.20	3	25.60	4	32.00	5	38.40	6	44.80	7	51.20
2	**0**	**32**	**0**	**6.60**	**1**	**13.20**	**2**	**19.80**	**3**	**26.40**	**4**	**33.00**	**5**	**39.60**	**6**	**46.20**	**7**	**52.80**
2	...	...																
2	F	47	0	9.60	1	19.20	2	28.80	3	38.40	4	48.00	5	57.60	6	67.20	7	76.80
3	0	48	0	9.80	1	19.60	2	29.40	3	39.20	4	49.00	5	58.80	6	68.60	7	78.40
3	...	...																
3	F	63	0	12.80	1	25.60	2	38.40	3	51.20	4	64.00	5	76.80	6	89.60	7	102.40
4	**0**	**64**	**0**	**13.00**	**1**	**26.00**	**2**	**39.00**	**3**	**52.00**	**4**	**65.00**	**5**	**78.00**	**6**	**91.00**	**7**	**104.00**
4	..	..																
4	F	79	0	16.00	1	32.00	2	48.00	3	64.00	4	80.00	5	96.00	6	112.00	7	128.00
5	0	80	0	16.20	1	32.40	2	48.60	3	64.80	4	81.00	5	97.20	6	113.40	7	129.60
5	...	...																
5	F	95	0	19.20	1	38.40	2	57.60	3	76.80	4	96.00	5	115.20	6	134.40	7	153.60
6	0	96	0	19.40	1	38.80	2	58.20	3	77.60	4	97.00	5	116.40	6	135.80	7	155.20
6	...	...																
6	F	111	0	22.40	1	44.80	2	67.20	3	89.60	4	112.00	5	134.40	6	156.80	7	179.20
7	0	112	0	22.60	1	45.20	2	67.80	3	90.40	4	113.00	5	135.60	6	158.20	7	180.80
7	1	113	0	22.80	1	45.60	2	68.40	3	91.20	4	114.00	5	136.80	6	159.60	7	182.40
7	...	...																
7	**F**	**127**	**0**	**25.60**	**1**	**51.20**	**2**	**76.80**	**3**	**102.40**	**4**	**128.00**	**5**	**153.60**	**6**	**179.20**	**7**	**204.80**

Update time: U = (N +1) * (SW3 +1) * .2 ms

SW2	SW1	N	SW3	U		U		U		U		U		U		U	SW3	U
0	**1**	**1**	**8**	**3.60**	**9**	**4.00**	**A**	**4.40**	**B**	**4.80**	**C**	**5.20**	**D**	**5.60**	**E**	**6.00**	**F**	**6.40**
0	**2**	**2**	**8**	**5.40**	**9**	**6.00**	**A**	**6.60**	**B**	**7.20**	**C**	**7.80**	**D**	**8.40**	**E**	**9.00**	**F**	**9.60**
0	3	3	8	7.20	9	8.00	A	8.80	B	9.60	C	10.40	D	11.20	E	12.00	F	12.80
0	**4**	**4**	**8**	**9.00**	**9**	**10.00**	**A**	**11.00**	**B**	**12.00**	**C**	**13.00**	**D**	**14.00**	**E**	**15.00**	**F**	**16.00**
0	...	...																
0	**8**	**8**	**8**	**16.20**	**9**	**18.00**	**A**	**19.80**	**B**	**21.60**	**C**	**23.40**	**D**	**25.20**	**E**	**27.00**	**F**	**28.80**
0	...	...																
0	F	15	8	28.80	9	32.00	A	35.20	B	38.40	C	41.60	D	44.80	E	48.00	F	51.20
1	**0**	**16**	**8**	**30.60**	**9**	**34.00**	**A**	**37.40**	**B**	**40.80**	**C**	**44.20**	**D**	**47.60**	**E**	**51.00**	**F**	**54.40**
1	...	...																
1	F	31	8	57.60	9	64.00	A	70.40	B	76.80	C	83.20	D	89.60	E	96.00	F	102.40
2	**0**	**32**	**8**	**59.40**	**9**	**66.00**	**A**	**72.60**	**B**	**79.20**	**C**	**85.80**	**D**	**92.40**	**E**	**99.00**	**F**	105.60
2	...	...																
2	F	47	8	86.40	9	96.00	A	105.60	B	115.20	C	124.80	D	134.40	E	144.00	F	153.60
3	0	48	8	88.20	9	98.00	A	107.80	B	117.60	C	127.40	D	137.20	E	147.00	F	156.80
3	...	...																
3	F	63	8	115.20	9	128.00	A	140.80	B	153.60	C	166.40	D	179.20	E	192.00	F	204.80
4	**0**	**64**	**8**	**117.00**	**9**	**130.00**	**A**	**143.00**	**B**	**156.00**	**C**	**169.00**	**D**	**182.00**	**E**	**195.00**	**F**	**208.00**
4	..	..																
4	F	79	8	144.00	9	160.00	A	176.00	B	192.00	C	208.00	D	224.00	E	240.00	F	256.00
5	0	80	8	145.80	9	162.00	A	178.20	B	194.40	C	210.60	D	226.80	E	243.00	F	259.20
5	...	...																
5	F	95	8	172.80	9	192.00	A	211.20	B	230.40	C	249.60	D	268.80	E	288.00	F	307.20
6	0	96	8	174.60	9	194.00	A	213.40	B	232.80	C	252.20	D	271.60	E	291.00	F	310.40
6	...	...																
6	F	111	8	201.60	9	224.00	A	246.40	B	268.80	C	291.20	D	313.60	E	336.00	F	358.40
7	0	112	8	203.40	9	226.00	A	248.60	B	271.20	C	293.80	D	316.40	E	339.00	F	361.60
7	1	113	8	205.20	9	228.00	A	250.80	B	273.60	C	296.40	D	319.20	E	342.00	F	364.80
7	...	...											D				F	
7	**F**	**127**	**8**	**230.40**	**9**	**256.00**	**A**	**281.60**	**B**	**307.20**	**C**	**332.80**	**D**	**358.40**	**E**	**384.00**	**F**	**409.60**

Update time: U = (N +1) * (SW3 +1) * .2 ms

RS422 PERSONALITY MODULE

Installing an RS422 Personality Module (RPM)

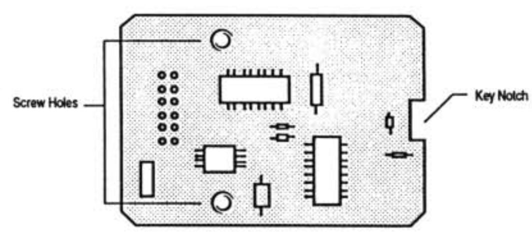
To assure full coverage under warranty and error-free future replication orders, install this label as instructed in Step 9.

> **! CAUTION !**
> The RPM is a static sensitive device and should be treated as such. MTS recommends a static wrist wrap be worn during installation and that these procedures are conducted in a clean environment.

1. Place the transducer hex in a vise.
2. Unscrew the cover using hand pressure only. Note that cover has right hand threads. A specially designed cover wrench is available from MTS.

> **! CAUTION !**
> Hands must be clean. Ensure that no foreign material contacts the inside components.

3. Once the cover is removed, clean the inner threads of the cover and bracket with a lint free cloth. Spray ONLY the cover threads with Sherwin Williams #00217 Teflon® spray.
4. Remove the RPM from the static sensitive bag by holding the module by its edges.
5. Place provided insulator on the bracket.
6. Align the 12 pin connector on the interconnect board with the socket on the RPM, ensure pins are straight, and press gently until PM is securely inserted.
7. Once the module is inserted, secure with the 2 provided Plastite screws until snug. Do not over-tighten!
8. Carefully align the cover to the threads and hand tighten until snug against the gasket.
9. Once cover is secure, attach the label provided as shown in Figure 2.



RPM Module

Figure 1

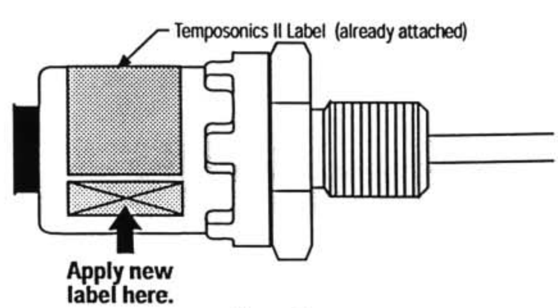


Figure 2

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MTS®

Sensors Division

TEMPOSONICS™

Linear Displacement Transducer System with Analog Output

Installation and Instruction Manual

List of Figures

List of Tables

1 Introduction

The Temposonics™II Linear Displacement Transducer measurement system (with analog output) precisely senses the position of an external magnet to measure displacements with a high degree of resolution. The system measures the time interval between an interrogating pulse and a return pulse. The interrogating pulse is transmitted through the transducer waveguide, and the return pulse is generated by a movable permanent magnet representing the displacement to be measured.

The system includes a linear displacement transducer (LDT), a magnet, and an analog output module (AOM). The AOM generates the interrogating pulse, senses the return pulse, and develops an analog output signal.

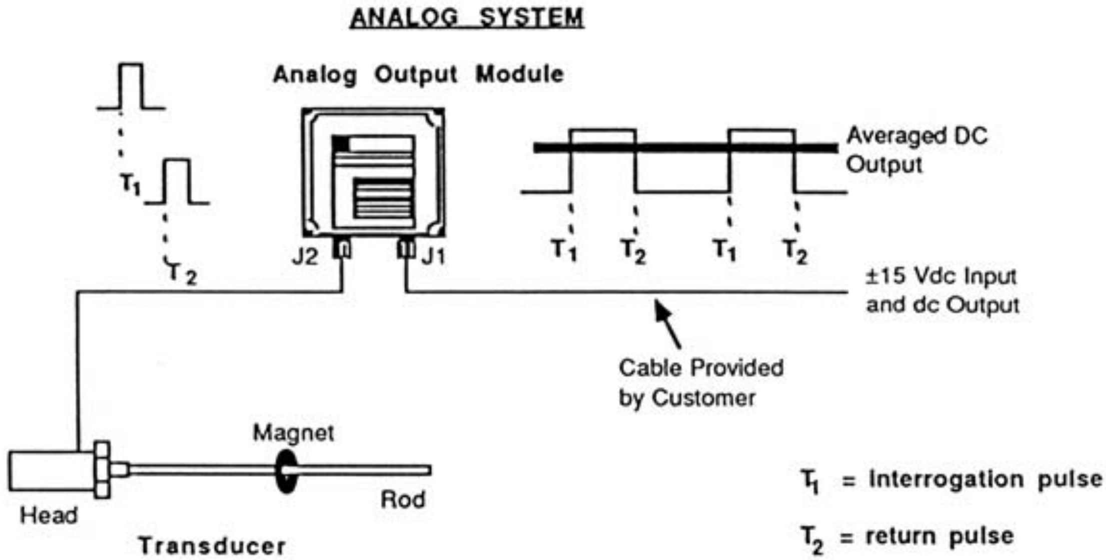


Figure 1-1. Linear Displacement Transducer System

Specifications

Parameter	Specification
Input voltage	+15 Vdc (±2%) at 250 mA, with <1% ripple -15 Vdc (±2%) at 65 mA, with <1% ripple
Displacement	Up to 30 feet (9 meters)
Nonlinearity	< ±0.05% of full scale or minimum ±0.002 in.(±0.05 mm)
Repeatability	< 0.001% of full scale or 0.0001 in.(0.0025 mm), whichever is greater
Frequency response	Depends on length and type of filtering. 200 Hz to 50 Hz is typical for lengths of 12 in. (30 cm) to 100 in. (254 cm) respectively. Wider response is available.
Temperature coefficient:	
Transducer	0.00018 inch/°F (0.00011 inch) ≤12 inches stroke) + 3ppm/°F/inch stroke - transducer 5ppm/°F nominal for external electronics
Analog Output Module	20 ppm/°F
Operating temperature:	
Transducer	-40 to 180 °F (-40 to 82 °C)
Analog Output Module	35 to 150 °F (2 to 66 °C)* Standard until July 1, 1990 -40 to 180°F (-40 to 82°C) Standard after July 1, 1990
Operating pressure	transducer rating 3000 psi (21 MPa) cyclical: 5000 psig (34 Pa) static
Output	0 to 10 Vdc and a other voltages are optional.
Output impedance	< 10 Ω
Velocity output	0 to ±10 Vdc, positive traveling away from the LDT head assembly, negative traveling towards the LDT head assembly
Standard features of Analog Output Module	External noise rejection circuitry to eliminate EMI noise from motors, relays, or other sources. Low ripple filter to reduce ac ripple on the output signal to .5 mV maximum

* Options available

Specifications are subject to change without notice. Contact MTS for verification of specifications [illegible]

2 Adjustments

This section explains how to adjust and calibrate the Temposonics Linear Position Transducer (LDT) system with analog output.

The Analog Output Module (AOM) includes adjustments for *null* (zero), and *full-scale* (span). The adjustments compensate for the following:

- differences between transducer *gradients*.
- small offsets in the magnet position due to mounting.
- wear in the moving parts of the mechanical system to which the magnet is attached.

In cases where a coupler device is used for adjusting the magnet (as described in Section 4), the coupler is used for coarse adjustments of both null and scale, while the AOM is used for fine adjustments.

Nominal Range of Adjustment

Null: From $\pm\frac{3}{8}$ inch up to ±3% of total stroke

Full-scale: ±2% of total stroke

Figure 2-1 shows the location of position adjustments and terminal boards on the AOM.

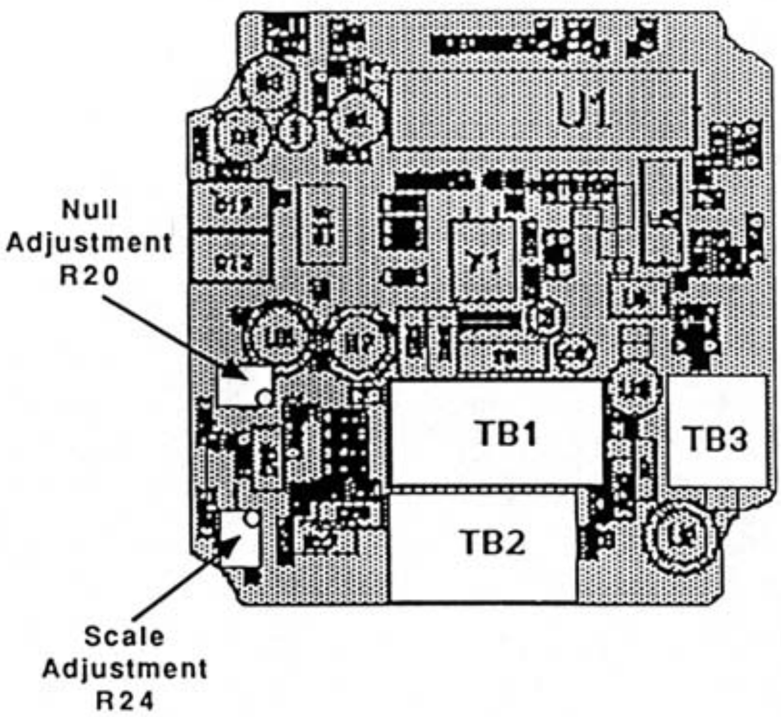


Figure 2-1. Location of Position Adjustments and Terminal Boards on the AOM.

NOTE

The adjustment values specified in the following procedures depend on the system configuration. The adjustment tolerances of these procedures during field calibration are dependent on system requirements and available test equipment.

Null and Full-Scale Adjustments

The following procedures calibrate the null position and the full-scale position to the required output levels. If the following adjustments are inadequate, refer to Subsection 3.2 for possible mechanical adjustments. Refer to Figure 2-1 for the adjustment locations.

NOTE

The following procedure assumes the standard full-scale 0 to 10 Vdc output is supplied. When other output signals are supplied, use the appropriate signal levels and test equipment for the following adjustments.

1. Disconnect all power from the system. Loosen the four screws securing the AOM cover, and remove the cover.

2. Note the location of terminal board TB1 on the AOM (Refer to Figure 2-1). Connect a DVM (digital voltmeter) across pins A and B of terminal board TB1 to monitor the displacement signal. Apply power to the system.

3. Position the permanent magnet at the specified null position. The null position is specified when the LDT assembly is ordered (typically 2 inches from the transducer head).

4. Use a screwdriver to adjust the *null potentiometer* (R20) clockwise to increase the value, or counterclockwise to decrease the value, until you obtain a DVM reading of 0.000 Vdc.

5. Position the permanent magnet for full-scale position (typically 5 or 7 inches from the end of the LDT assembly).

6. Use a screwdriver to adjust the *scale potentiometer* (R24) clockwise to increase the value, or counterclockwise to decrease the value, until you obtain a DVM reading of +10.000 Vdc.

7. Repeat steps 3 to 6 to check the null and full-scale settings. Readjust as necessary.

8. Disconnect the DVM and check overall system operation. If no more adjustments are necessary, replace the AOM cover.

Velocity Null Adjustment

Some AOM units are designed to provide velocity output. For those units, velocity null and velocity scale adjustments are provided. The velocity null and velocity scale adjustments are factory set and should not require readjustment. The velocity output signal represents a static displacement (no motion) by 0 volts and the maximum velocity of a dynamic displacement by 10 volts. The direction of motion is indicated by the polarity of the velocity signal; a positive signal normally indicates the permanent magnet is moving away from the transducer head (unless otherwise specified for this system).

The following procedure provides the velocity null adjustment; the velocity full-scale adjustment requires special equipment. Refer to Figure 2-2.

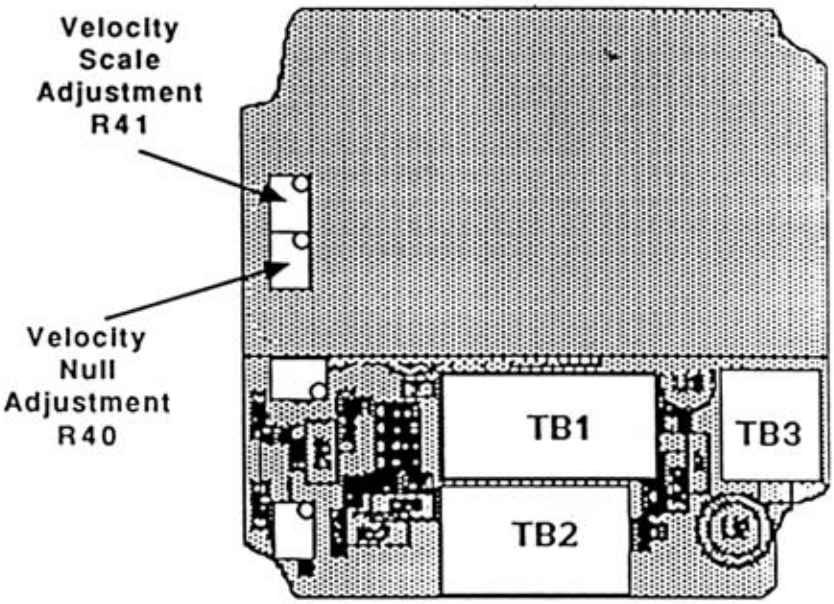


Figure 2-2. Velocity Adjustments on the AOM

NOTE

Velocity scale adjustment may be difficult in the field, because it requires precision equipment to control and measure the exact velocity.

1. Disconnect all power from the system. Loosen the four screws securing the AOM cover, and remove the cover.
2. Note the location of terminal board TB1 on the AOM (Refer to Figure 2-2). Connect a peak reading DVM (digital voltmeter) or oscilloscope across pins C and D of terminal board TB1 to monitor the velocity signal. Apply power to the system.
3. Make sure the permanent magnet is not moving.
4. Adjust the velocity null control (R40) clockwise to increase the value, or counterclockwise to decrease the value, until you obtain a DVM or oscilloscope reading of 0.000 Vdc.
5. Disconnect the DVM or oscilloscope and check overall system operation. If no more adjustments are necessary, replace the AOM cover.

3 Mounting Procedures

This section describes mounting procedures for the Linear Displacement Transducer measurement system, under the following headings:

- Installing the Analog Output Module
- Installing Rigid Transducers
- Installing Flexible Transducers
- Transducer Supports
- Spring Loading or Tensioning
- Cylinder Installation
- Installing Magnets

Specific installation procedures depend on the application.

Installing the Analog Output Module

Overall and mounting dimensions for the analog output module (AOM) are shown in Figure 3-1. The mounting hole dimensions shown are also stamped on the back of the module. The AOM is mounted as shown, using two socket head cap screws.

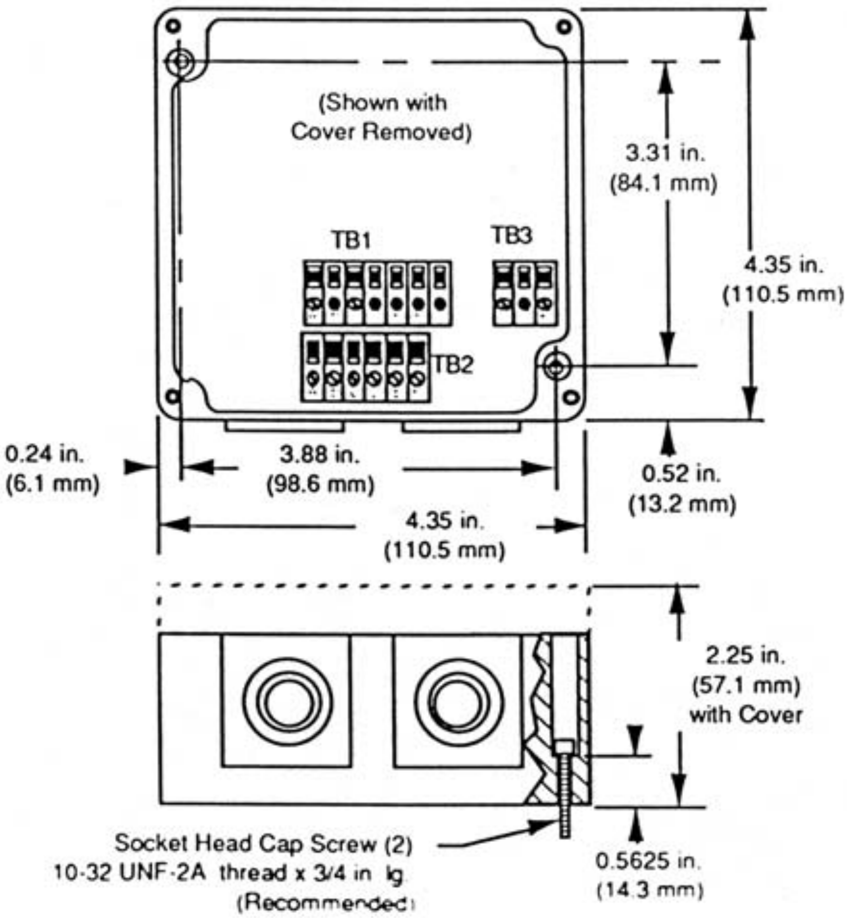


Figure 3-1 Overall Dimensions, AOM

Installing a Rigid Transducer

Before beginning installation, be sure you know the following dimensions(as illustrated in Figure 3-2):

- null space
- stroke
- dead zone

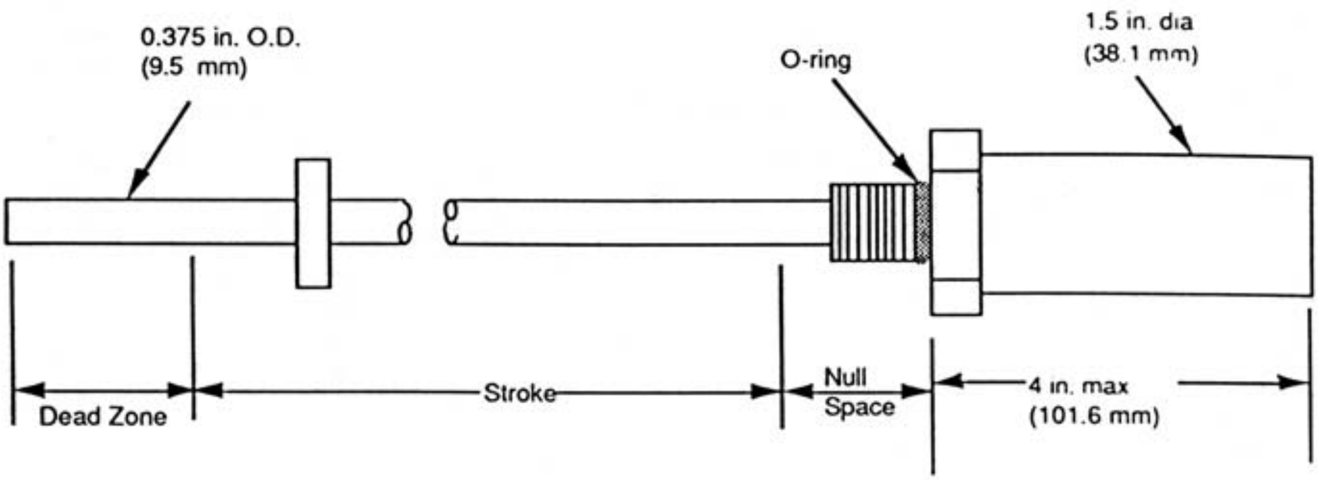
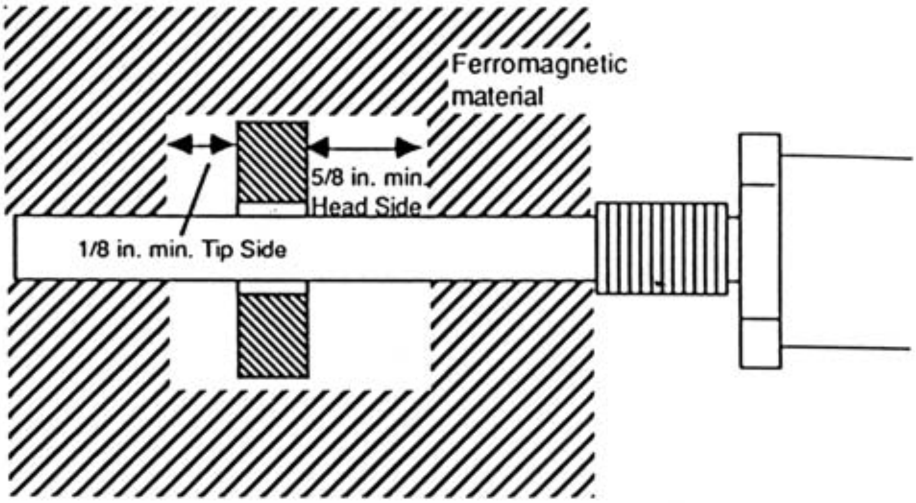


Figure 3-2. LDT Assembly

1. Use the 3/4 inches (19 mm), 16 UNF thread of the transducer to mount it at the selected location. Leave room to access the hex head. If a pressure or moisture seal is required, install an O-ring (type MS 28778-8 is recommended) in the special groove . Use the hex head to tighten the transducer assembly.

2. Install the permanent magnet over the LDT rod. Mount the permanent magnet to the movable device whose displacement will be measured. To minimize the effect of magnetic materials (i.e. iron, steel, etc) on the magnetic field of the permanent magnet, ensure the minimum spacing requirements are met as shown in Figure 3-3. (Any non-magnetic materials can be in direct contact with the permanent magnet without affecting performance.)

The magnet must not contact ferromagnetic materials (such as iron or steel). Clearances are required between the surface of the magnet and ferromagnetic material as shown. Non-ferrous material (such as copper, brass, or 300 series stainless steel) may contact the magnet without affecting transducer performance.



Standard null space is 2 inches. There is no maximum limit on null space. Less than 2 inches null space can be specified as long as magnet clearances are observed as shown above. The examples below illustrate minimum clearances.

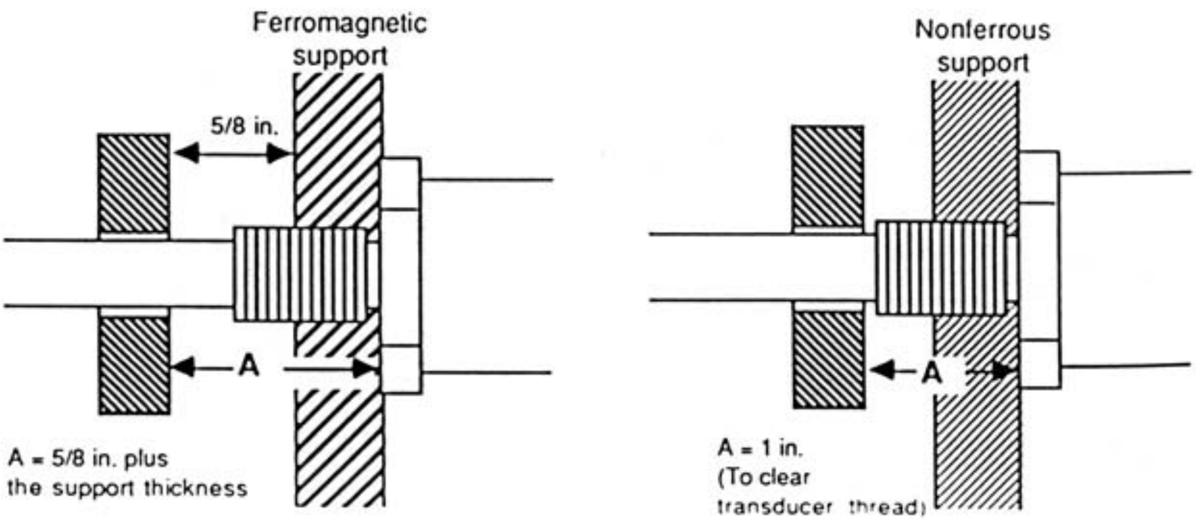


Figure 3.3 Magnetic Material Mounting Specifications

NOTE

Clearance between the magnet and the LDT rod is not critical. However, contact between the components will cause wear over time. The installation of supports or readjustment of the supports is recommended if the magnet contacts the LDT rod.

3. Move the permanent magnet full-scale to check that it moves freely. If not (if the magnet rubs on the LDT) you can correct this by mounting a support bracket to the end of the LDT. Long transducers may need additional supports to be attached to the transducer rod. Transducer supports are described later in this section.

4. Mount the analog output module in a location within reach of the LDT assembly cable. Standard systems allow the analog output module to be mounted 250 feet of the LDT assembly.

5. Connect the cable from the AOM to the transducer assembly.

6. Adjust the AOM null and full-scale potentiometers (as described in Section 2) to compensate for any offsets due to mechanical installation.

Installing a Flexible Transducer

Before beginning installation, be sure you know the following dimensions (as illustrated in Figure 3-4)

- null space
- stroke
- dead zone

Review the following considerations:

- Each flexible transducer is custom manufactured for a specific application and installation. The specific requirements (which are determined before ordering) include specific curvatures and straight sections at specific distances from the transducer head.
- A flexible transducer should not be subjected to temperatures above 130°F (54°C) unless specified. The temperature of the transducer rod should not vary more than ±30°F (±16°C) unless specified.
- A flexible transducer should not be subjected to pressures above atmospheric pressure.
- A flexible transducer can be flexed or curved to a standard diameter of 36 in. (91 cm) during installation. Consult MTS for specific applications.
- A flexible transducer requires supports or anchoring to maintain the designed shape. Transducer supports are described later in this section
- Some long transducers are ordered as flexible units to facilitate shipping and handling only, even though they are for straight applications.

⚠ CAUTION

DO NOT attempt to install a flexible transducer without knowing the design installation dimensions. Failure to follow the design dimensions can result in improper operation or transducer damage.

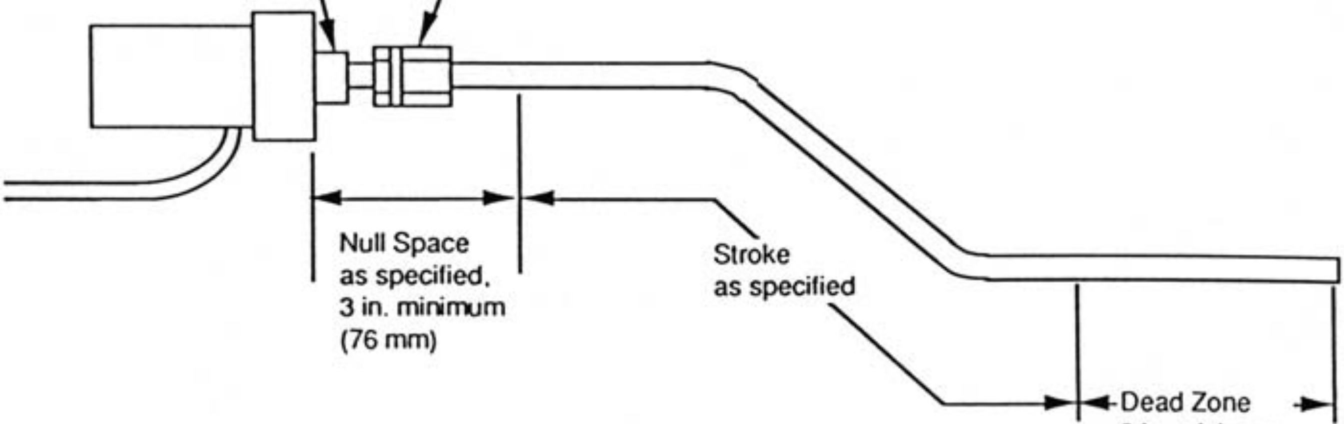


Figure 3-4. Flexible Transducer

Take the following steps to install a flexible transducer.

⚠ CAUTION

DO NOT loosen or mount the transducer using the polypropylene fitting near the transducer head. This will cause damage to the transducer.

1. A transducer supplied with a 1 inch O.D. head flange requires a U-bolt, flange collar or similar clamping device to keep the transducer head stationary.

2. Install the permanent magnet over the LDT rod. Mount the permanent magnet to the movable device whose displacement will be measured. To minimize the effect of magnetic materials (i.e. iron, steel, etc) on the magnetic field of the permanent magnet, ensure the minimum spacing requirements are met as shown in Figure 3-3. (Any non-magnetic materials can be in direct contact with the permanent magnet without affecting performance)

3 Mount the analog output module (AOM) in a location within reach of the LDT cable. Standard systems allow the AOM to be mounted a standard of 250 feet of the LDT assembly

4. Mount the required transducer supports. (Transducer supports are described later in this section.

5. Connect the cable from the AOM to the transducer assembly.

6. Adjust the AOM null and full-scale potentiometers (as described in Section 2) to compensate for any offsets due to mechanical installation.

Types of Transducer Supports

Long transducers (4 feet or more) may require supports to maintain proper alignment between the transducer rod and the permanent magnet. All flexible transducers likewise require supports to obtain the design shape. When transducer rod supports are used, special permanent magnets are required.

Transducer supports attached to the active stroke length must be made of a non-ferrous material, thin enough to permit the permanent magnet to pass without obstruction. Because the permanent magnet does not enter the dead zone, supports connected within the dead zone may be made of any material. The main types of supports are loop, channel, and guide pipe supports.

Loop Supports

Loop supports are fabricated from non-ferrous materials, thin enough to permit free movement of the magnet. Loop supports are recommended for straight transducers. They may be used alone or with channel supports. Figure 3-5 illustrates the fabrication of a loop support.

NOTE

When open magnets are used, ensure the transducer rod remains within the inside diameter of the magnet throughout the length of the stroke. If the transducer rod is allowed to enter the cut out area of an open magnet, the transducer signal will be lost.

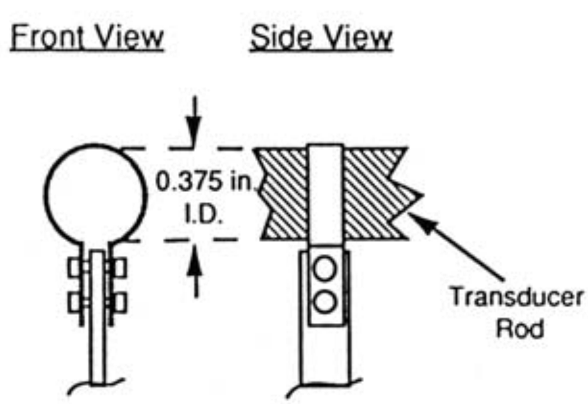


Figure 3-5. Loop Support

Channel Supports

Channel supports, being typically straight, are normally used with rigid transducers. A channel support consists of a straight channel with loop supports mounted at intervals. The loop supports are required to keep the transducer within the channel. Figure 3-6 shows a channel support. Channel supports are available from various manufacturers or may be fabricated.

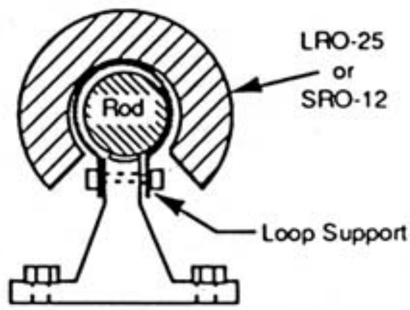


Figure 3-6. Channel Support

Guide Pipe Supports

Guide pipe supports are normally used for flexible transducers. A guide pipe support is constructed of non-ferrous material, straight or bent to the desired shape. As shown in Figure 3-7, both inside and outside dimensions of the pipe are critical:

- Because the transducer rod is installed inside the pipe, the inside diameter of the pipe must be large enough to clear the rod.
- The outside diameter of the pipe must be small enough to clear the magnet.

Refer to pipe manufacturers' specifications and dimensions (schedule 10, 40, etc) to select the appropriate size pipe. Guide pipe is typically supported at each end of the pipe.

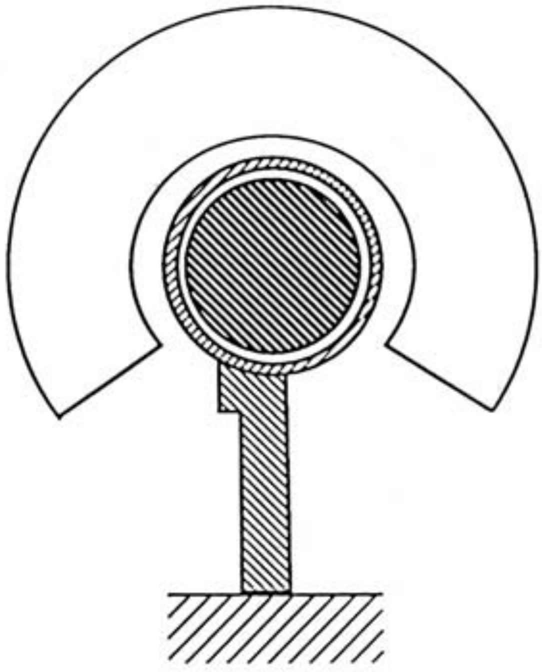


Figure. 3-7. Guide Pipe Support

Open Magnets

When using an open magnet, make sure the rod is positioned at all times within the "active" zone of the magnet. The transducer cannot operate properly unless the entire stroke of the transducer rod is located within this zone. The active zone, as shown in Figure 3-8, lies within the inside diameter of the magnet.

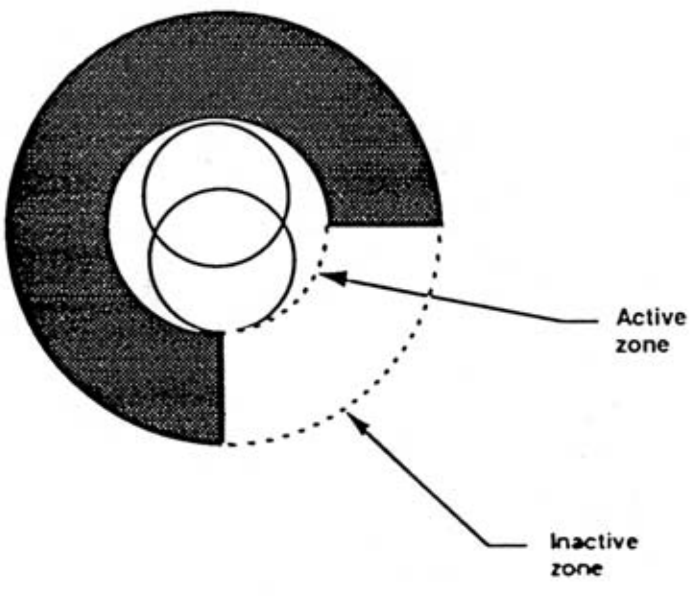


Figure 3-8. Active Zone for Open Magnets

Spring Loading or Tensioning

The transducer rod (flexible or rigid) can be spring loaded or tensioned using a stationary weight. Attach a spring mechanism or weight to the dead zone of the transducer rod with a clamping device which will not deform the transducer rod. The maximum weight or spring tension is 5 to 7 lbs. Spring loading or tensioning is recommended for vertical transducer installations.

Cylinder Installation

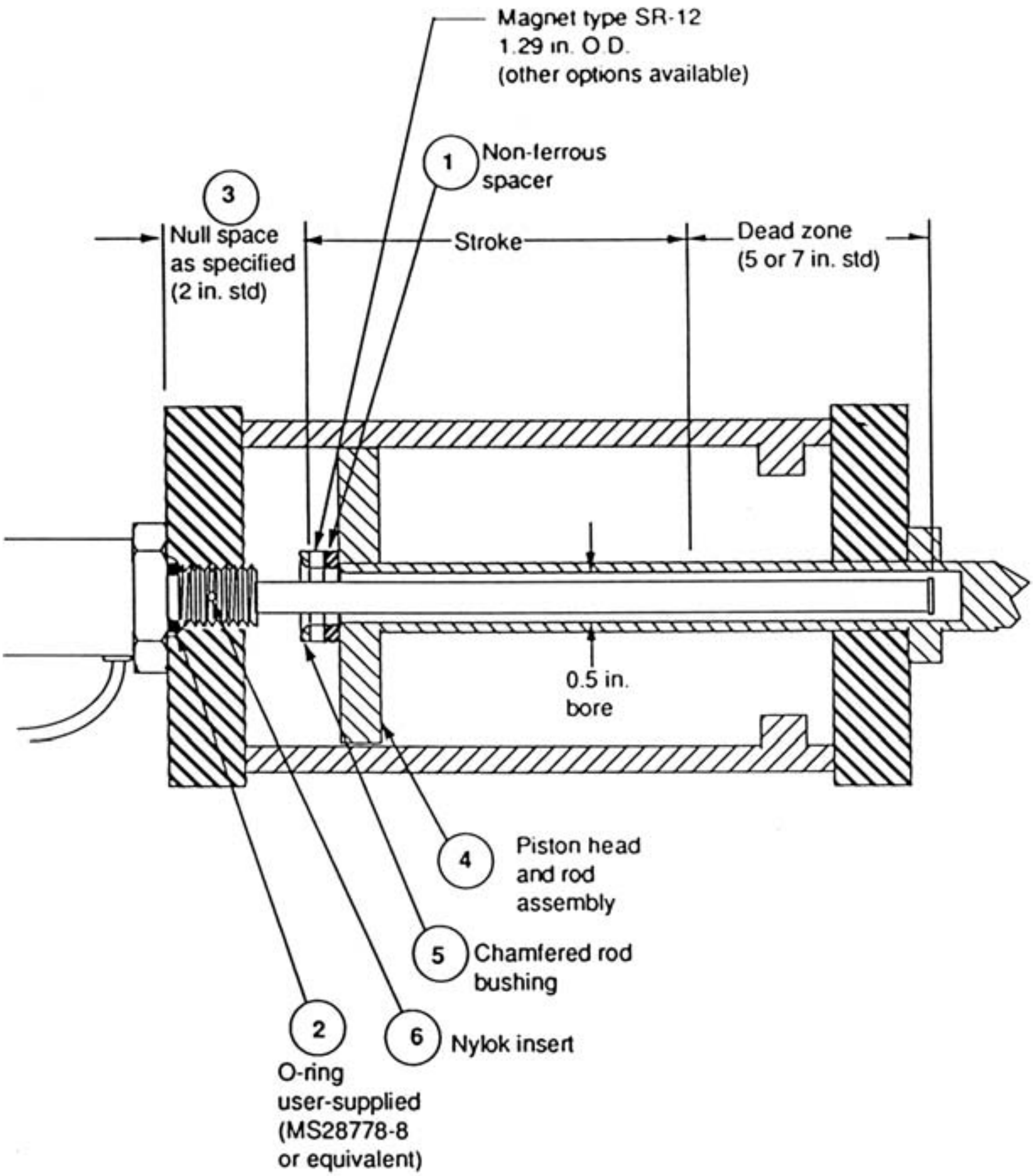


Figure 3-9. Typical Cylinder Installation

The rigid transducer installation procedure can be used as a guide for cylinder installations. Figure 3-9 shows a typical cylinder installation. Review the following before attempting this type of installation.

- Use a non-ferrous (plastic, brass, teflon, etc) spacer [1] to provide 1/8 inch (32 mm) minimum space between the magnet and the piston.
- An O-ring groove [2] is provided at the base of the transducer hex head for pressure sealing. MTS uses mil-standard MS33514 for the O-ring groove. Refer to mil-standard MS33649 or SAE J514 for machining of mating surfaces.
- The null space [3] is specified according to the installation design and cylinder dimensions. The analog output module provides a null adjustment. Make sure that the magnet can be mounted at the proper null position.
- The piston head [4] shown in Figure 3-9 is typical. For some installations, depending on the clearances, it may be desired to countersink the magnet.
- A chamfered rod bushing [5] should be considered for stokes over 5 feet (1.5 meters) to prevent wear on the magnet as the piston retracts. The bushing should be made from teflon or similar material.
- A nylok self locking insert [6] is provided on the transducer threads. An o-ring groove is provided at the base of the transducer hex head for pressure sealing.
- The recommended bore for the cylinder rod is 1/2 inch (13 mm). The transducer rod includes a .375 inch flush (12 mm) end plug; a flush end plug is available. Use standard industry practices for machining and mounting of all components. Consult the cylinder manufacturer for applicable SAE or military specifications.

Installing Magnets

If the null adjustment is inadequate, you can design a coupler with adjustments to mount the magnet to the measured member.

4 Wiring Procedures

This section describes general wiring procedures for the following types of analog output systems:

- 0 to 10 V displacement
- -10 to +10 V displacement
- Ungrounded 4 to 20 mA displacement
- Grounded 4 to 20 mA displacement

All other types of systems are described in Appendixes A and B at the back of this manual.

Connections are made between the transducer assembly, the analog output module (AOM), the customer-supplied power supply, and the customer-supplied receiving device.

Preparing Cable for Connection to the AOM

The AOM is equipped with two strain reliefs or two MS (mil-spec) connectors.

A strain relief is used for an unterminated cable. Prepare the cable as shown in Figure 4-1. It is recommended that you tin the exposed leads to ensure a good connection. Mount the cable to the AOM, ready to make connections to the terminal boards (TB1, TB2, or TB3) inside.

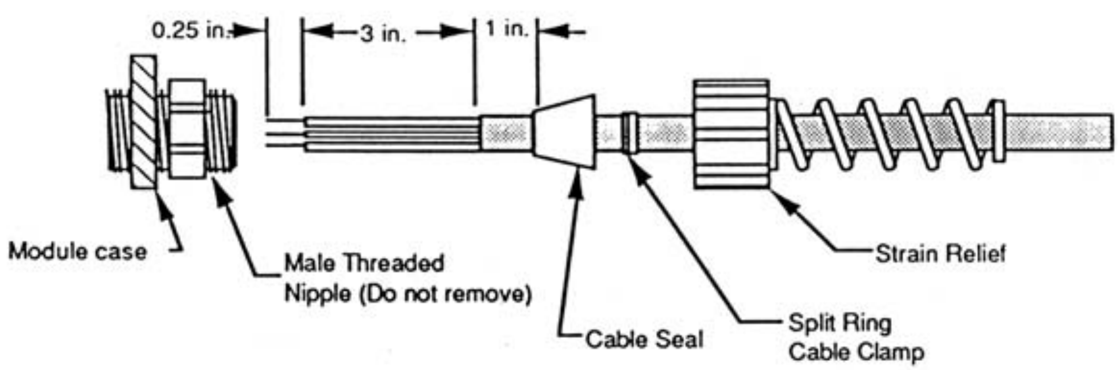


Figure 4-1. Cable Preparation for Strain Relief

When an MS connector is used, the correct matching connector is provided. In this case, strip and prepare the cable for soldering to the matching connector.

J1 Connections

The J1 cable provides the AOM voltage inputs from the customer-supplied power supply. It also provides displacement outputs to the customer-supplied receiving device.

Take the following steps to connect J1:

1. One of the screws securing the cover of the AOM has a raised head. Connect a ground wire from that screw head to a central earth ground or to the power supply ground (if it is grounded). Only one circuit earth ground should be used to prevent ground loops. (Refer to Figure 4-5 at the end of this section for a full system grounding diagram.)

2. **Strain Relief Only:** Fabricate the J1 cable, and prepare the cable as described earlier. Identify the connections to TB1 and TB3. Refer to Figure 4-2 (or 4-3 for velocity output) to determine the appropriate J1 connections.

3. **MS Connector Only:** Fabricate the J1 cable. Refer to Tables 4-1 through 4-3 to determine the appropriate J1 connections. Solder the connections to the type MS 3106 A 14S-5S connector supplied with the AOM. Use any cable capable of maintaining the signals for the required length. Ensure the solder connections are clean and free of excessive solder. Use heat-shrink over the solder connections to prevent the pins from shorting.

4. Identify the wires at the other end of cable for connections to the power supplies and the receiving device. Test the cable for shorts.

> **NOTE**
>
> Make sure that the power supply can provide +15 Vdc at 250 mA and -15 Vdc at 65 mA (use a bipolar power supply). The power supply should provide less than 1% ripple with 1% regulation. The power supply should be dedicated to the transducer system to prevent noise and external loads from affecting the system performance.

5. Make sure the power supply is off. Complete the cable connections at the power supply.

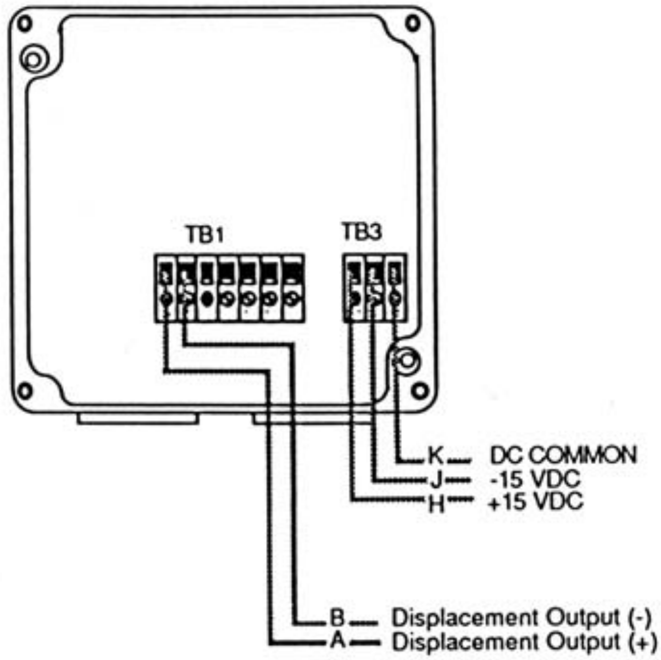


Figure 4-2. J1 Connections (Strain Relief)

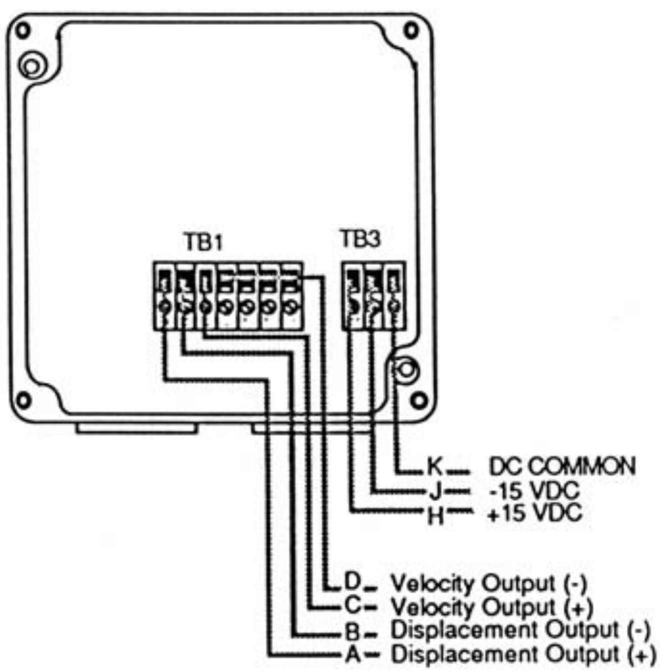


Figure 4-3. J1 Connections—Velocity Output (Strain Relief)

Table 4-1. Voltage Output J1 Connections (MS Connector)

J1 pin	Description
A	+15 Vdc
B	-15 Vdc
C	DC Common
D	Displacement
E	Optional output signals*

*Optional velocity or pulse-width modulated signal as second output.

Table 4-2. Ungrounded 4-20 mA Current Output J1 Connections (MS Connector)

J1 pin	Description
A	+15 Vdc
B	-15 Vdc
C	DC Common
D+	Current Output (source)*
E-	Current Output (return)*

*Do not ground or damage may result. Maximum load resistance: 400 Ω.

Table 4-3. Grounded 4-20 mA Current Output J1 Connections (MS Connector)

J1 pin	Description
A	+15 Vdc
B	-15 Vdc
C	DC Common and - Current (return)*
D+	+Current (source)
E-	(not connected)

*Maximum load resistance 500 Ω

CAUTION

The input to the receiver electronics should be a passive, resistive device to prevent damage to the AOM.

6. First, make sure there is no voltage present on the receiving device input connections. Then, complete the cable connections to the receiving device.

NOTE

Do not route the J1 cable near high voltage sources.

7. **Strain Relief Only:** Connect the cable to the TB1 and TB3 terminals on the AOM.

8. **MS Connector Only:** Connect the cable to the J1 connector on the AOM.

J2 Connections

The J2 cable provides connections between the AOM and the transducer assembly.

- Cables up to 20 ft (6 meters) can be fabricated with any high quality multiconductor cable with an overall shield (Belden equivalent).
- The recommended cable for 20 ft (6 meters) to 100 ft (30 meters is Belden 9931 or Belden 83506 teflon (or equivalents).
- Cable lengths of 50 to 100 ft (15 to 30 meters) may need impedance matching. Consult the Sensors Division of MTS if operational problems are encountered.
- The recommended cable for 100 to 250 ft (30 to 75 meters) is Belden 9730 or equivalent. The transducer assembly must include the optional cable driver for this cable range.

NOTE

The blue cover of the transducer assembly is at circuit ground and should not be grounded locally

Take the following steps to connect J2:

1. It is recommended that you apply an earth ground to the transducer rod. This is typically accomplished by mounting the transducer head to a bracket or machine.

2. **Strain Relief Only:** If necessary, fabricate the J2 cable, and prepare the cable as described earlier. Identify the connections to TB2. Refer to Figure 4-4 for the J2 connections.

NOTE

Ensure the solder connections are clean and free of excessive solder. Use heat-shrink over the solder connections to prevent the pins from shorting.

3. **MS Connector Only:** If necessary, fabricate the J2 cable. Refer to Table 4-4 to determine the recom-mended mating connectors for the different trans-ducers. Be sure to use the recommended cable for the required length. Refer to Table 4-5 for the appropriate J2 connections. The color code refers to cables supplied with the system. Solder the connections to the MS connector supplied with the AOM. Use any cable capable of maintaining the signals for the required length. Ensure the solder connections are clean and free of excessive solder. Use heat-shrink over the solder connections to prevent the pins from shorting.

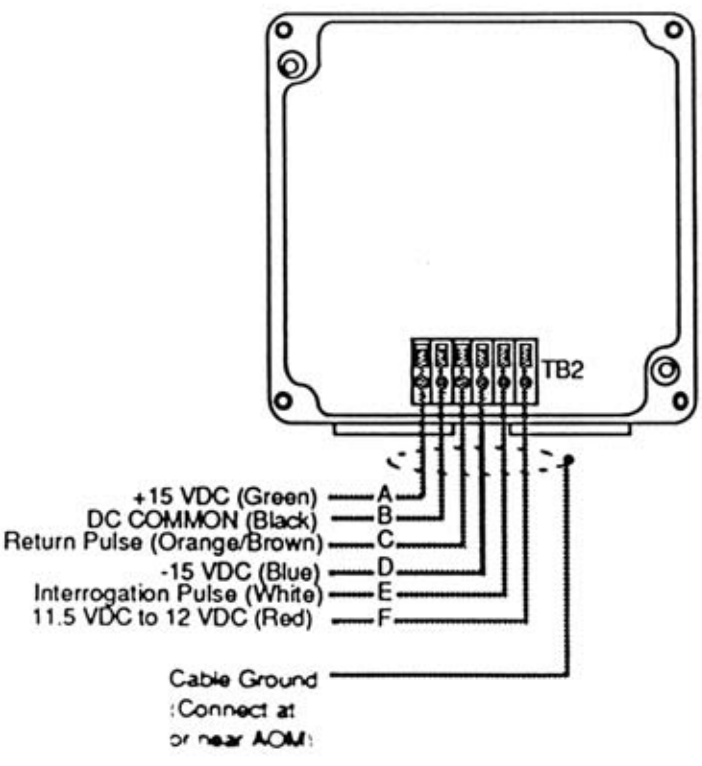


Figure 4-4 J2 Connections (Strain Relief)

4. **Strain Relief Only:** Connect the cable to the TB2 terminals on the AOM and to the transducer.

5. **MS Connector Only:** Connect the cable to the J2 connector on the AOM, and to the transducer.

6. Apply power and check the displacement readings at the system electronics.

Table 4-5. J2 Connections (MS Connector)

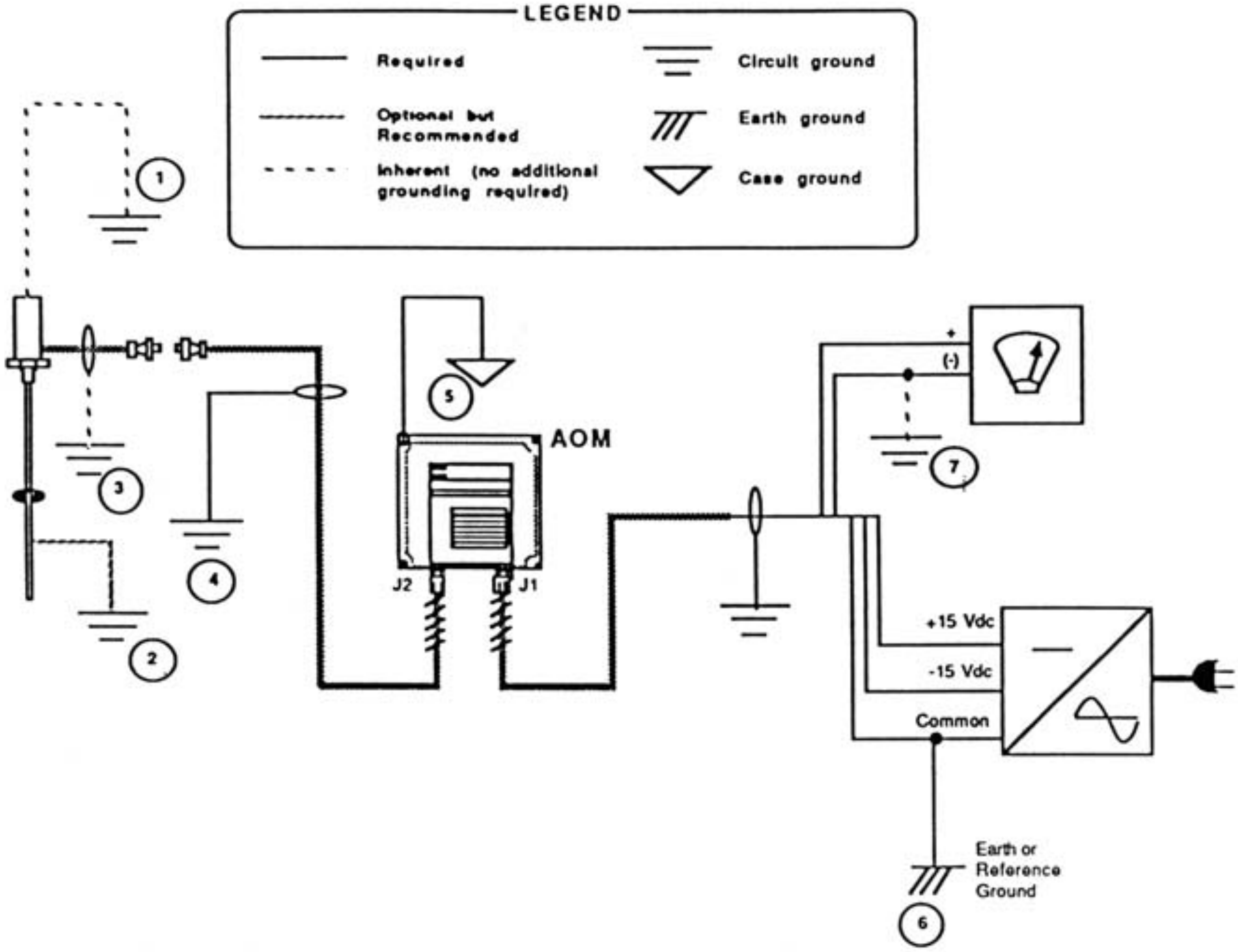
J2 Signal/Function	J2 Pin	Wire Color Code	Wire Color Code
		Integral Cable or Belden 9931 83506 Extension Cables	Belden 9730 wire/shield
+12 to +14.5 Vdc	A	Green	Black/Blue
DC Common/Ground	B	Black	Black/Red
Return pulse from transducer	C	Brown or Orange	Green/Blue
-13.5 to -14.5 Vdc	D	Blue	Black/Green
Interrogation Pulse to transducer	E	White	White/Green
+11.5 to +12Vdc transducer	F	Red	Red/Red
Cable Ground*		SHIELD - see below	

* Cable Grounds:

1. Cable shields are grounded at one end of the cable only.

2. An integral cable shield is connected to the circuit ground within the transducer head.

3. The extension cable shield should be connected to ground at the output module connector only. Apply ground by separate connection to earth ground or by connecting to pin B on the connector which mates to the box



1. Blue dust cover (NEMA 1) is at circuit ground. Do not apply additional ground. Stainless steel or aluminum ruggedized head cover (NEMA 4, NEMA 6) is at same potential as transducer rod.

2. (Optional) It is good practice to apply a machine, local, or earth ground to the transducer rod. This is normally accomplished by mounting to a grounded device.

3. Transducers with integral cable have circuit ground applied to the cable shield. The ground does not pass through the connector to the extension cable or AOM.

4. Connect extension cable shield to circuit ground or local earth ground at or near the AOM.

5. The AOM case is floating with respect to all grounds. It is good practice apply a local, earth or machine ground to this case. This is normally accomplished by mounting to a grounded device.

6. Circut or "reference" ground is established by connecting the power supply common(s) to earth ground. Do not apply additional grounds to circuit ground (at the transducer head, integral cable shield, or analog output).

7. All voltage and 4–20 mA grounded outputs have circuit ground applied to the negative lead through the internal construction of the AOM. Circuit ground therefore passes passes to the receiver device (-) terminal. If the receiver device (-) is grounded, it must use the same ground that is applied to the power supply common.

8. For 4–20 mA ungrounded output only, the (-) lead of the AOM output must remain isolated from circuit ground (and earth ground) or output will malfunction. Do not connect to a device which has ground applied to the (-) terminal.

Figure 4-[illegible] Grounding the Analog System

5 Troubleshooting

Use the troubleshooting procedures in this section when operational problems are encountered. The procedures are listed in order of frequency of occurrence, and should be completed in the order shown.

NOTE

The following procedures are for general diagnostic purposes. Purchase of replacement components should not be based solely on these procedures. Consult MTS Sensiors Division for recommendations and factory service before ordering replacement components.

General

Make sure the magnet is positioned to move freely along the LDT rod. Trace all wiring from the J1 connector to ensure proper routing.

Power Supply Check

Perform the following procedure to check the power supply voltages.

1. Remove power and disconnect connector J1 to check open circuit power supply voltages (as described in steps 2 and 3).

NOTE

If voltage is not present in steps 2 and 3, a problem with wiring or the power supply is indicated.

2. Connect a DVM (digital voltmeter) to pins A and C of cable connector J1. Apply power. The voltage should be +15 Vdc.

3. Connect the DVM to pins B and C of cable connector J1. The voltage should be -15 Vdc.

NOTE

A low voltage reading in steps 4 and 5 indicates a power supply with an inadequate rating or an excessive voltage drop in the cabling (i.e. improper wire sizes).

4. If the voltage readings are correct, check the power supply voltages under load (as described in steps 5 and 6).

5. Connect a 60 Ω to 75 Ω resistor across pins A and C. The voltage across the resistor should be +14.7 Vdc (min).

6. Connect a 230 Ω to 250 Ω resistor across pins B and C. The voltage across the resistor should be -14.7 Vdc (min).

Grounding

Trace all ground and power supply common connections. A single earth ground should be connected to the power supply common (circuit ground). An additional ground is connected to the case of the analog output module (AOM). If the AOM is suspect, remove the mounting screws and place the box on insulating material (i.e. wood) then recheck the output readings.

Connections

Check the solder connections in the J1 cable. Ensure no cold solder joints are present. Perform a continuity check between the J1 connections to ensure no shorts are present.

LDT Signals

Disconnect connector J2 from the AOM. Apply power and check the J2 readings, using Figure 5-1 and earlier Table 4-5. If the voltages are correct, connect J2 and check the signals at pins B and C with an oscilloscope. If the J2 readings are proper, refer to step A. If the J2 readings are not proper, refer to step B.

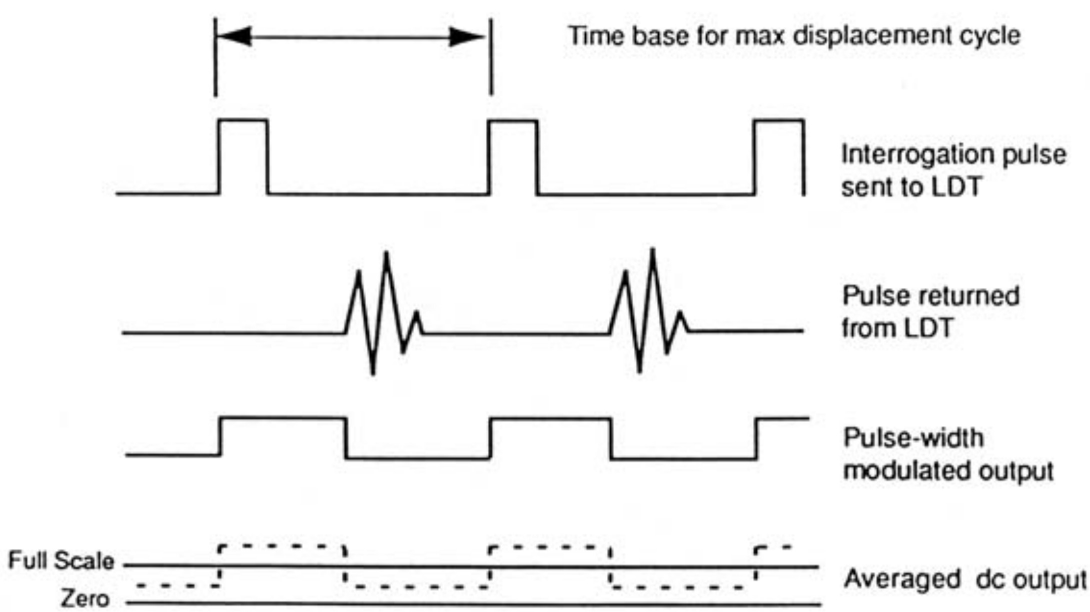


Figure 5-1 Analog Output Module Signals

NOTE

Do not interchange transducers and AOMs with differing model numbers, without first consulting MTS Sensors Division.

A. If a spare transducer of the same stroke and model number is available, connect the spare transducer to the AOM and check the displacement readings at the system electronics.

B. If a spare AOM of the same stroke model number is available, connect J1, J2 and the ground wire to the spare AOM and check the displacement readings at the system electronics.

Appendix A. J1 Wiring for Options

This appendix describes J1 wiring for non-standard options. J1 wiring includes all connections to TB1 and TB3. Table A-1 shows the TB1 connections for all available options. Wiring for the standard system (with displacement only) and for the velo-city output option is illustrated in Section 4. Wiring for all other options is shown in Figures A-1 to A-4 below

Table A-1. TB1 Pins

Output Option	Signal Description	Terminal	Color Code
Displacement Only (Voltage or Current)	Displacement Output (+) Displacement Output (-)*	A B	
Displacement and Velocity (Voltage or Current)	Displacement Output (+) Displacement Output (-)* Velocity Output (+) Velocity Output (-)*	A B C D	
Dual Channel Voltage	Channel A Displacement Output (+) Channel A Displacement Output (-) Channel B Displacement Output (+) Channel B Displacement Output (-)	A B E F	
Displacement Only with External Null or Scale Adjustment	Displacement Output (+) Displacement Output (-)* (not connected) (not connected) Potentiometer Top (fully CW end) Potentiometer Wiper Potentiometer Bottom (fully CCW end)	A B C D E F G	
Displacement and Velocity with External Null or Scale Adjustment	Displacement Output (+) Displacement Output (-)* Velocity Output (+) Velocity Output (-) Potentiometer Top (fully CW end) Potentiometer Wiper Potentiometer Bottom (fully CCW end)	A B C D E F G	

*Normally at ground potential except for ungrounded current output options.

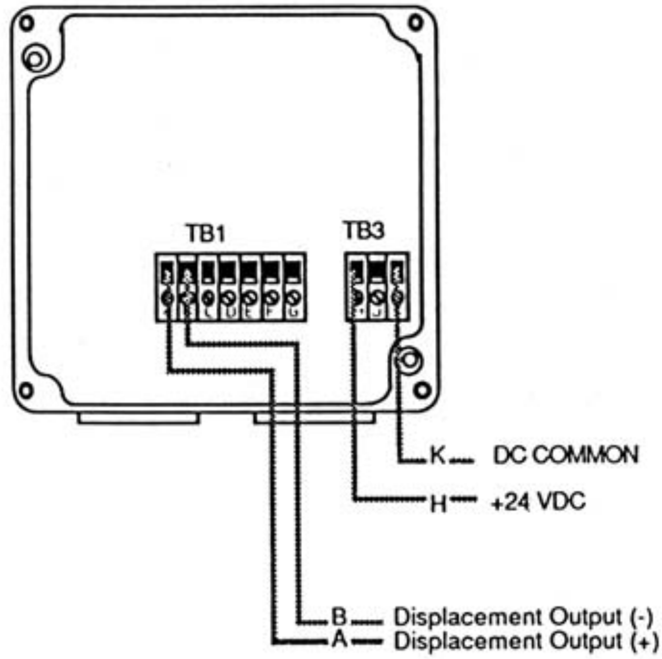


Figure A-1. J1 Connections—Displacement Only (24 Volt Option)

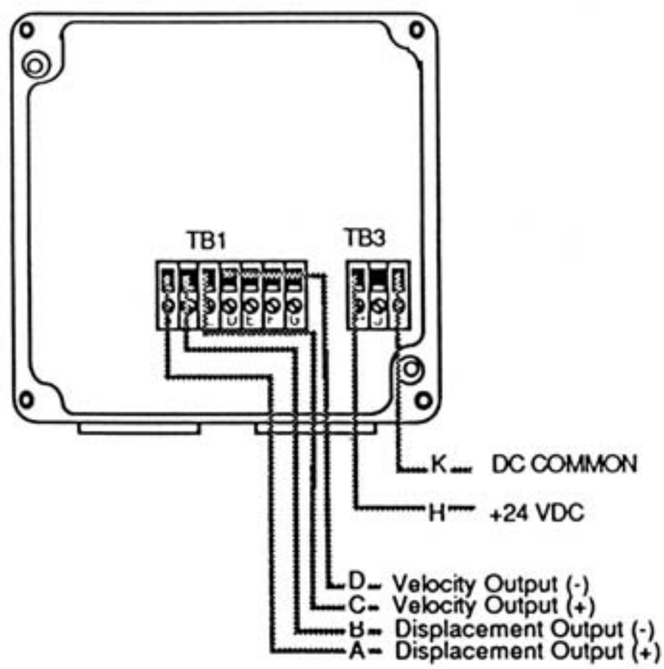


Figure A-2. J1 Connections—Velocity and Displacement (24 V Option)

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MTS®

Installation and Instruction Manual

Temposonics™ Brand Linear Displacement Transducer System with Direct Digital Output

Table of Contents

I. Introduction

II. Service

III. Installation

IV. Troubleshooting

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List of Figures

List of Tables

Model Coding

The system components (transducer, interface box and counter card) are identified by a model coding system which identifies all construction variables required to complete your system.

The following information is provided to aid in proper wiring and operation of the system purchased. Kindly keep this information in a safe place for future reference:

SALES ORDER ______________________________ DATE ______________

SYSTEM SERIAL NUMBER (S)	RESOLUTION	RECIRCS.	WIRING TABLE	CRYSTAL
1. ________	______	______	______	______ Mhz
2. ________	______	______	______	______
3. ________	______	______	______	______
4. ________	______	______	______	______
5. ________	______	______	______	______
6. ________	______	______	______	______
7. ________	______	______	______	______
8. ________	______	______	______	______
9. ________	______	______	______	______
10. ________	______	______	______	______

Linear Displacement Transducer (LDT)

Model Number ☐☐ ☐ ☐☐☐☐ ☐ ☐ ☐ ☐ ☐

STYLE
- 01 = Standard
- 02 = Small Ruggedized head - SRH
- 03 = Flexible
- XX = Special

STROKE UNITS
- 1 = inches and tenths
- 2 = mm
- 3 = inches and eighths

STROKE LENGTH
- E.G. 0120 = 12 inches or 120 mm
- 0365 = 36.5 inches or 365 mm or 36-5/8 inches
- 1200 = 120 inches or 1200 mm

NULL/DEAD SPACE
- 5 = 5 inch D.S. and 2 inch Null - (Standard for strokes up to 200 in.)
- 7 = 7 inch D.S. and 2 inch Null - (Standard for strokes over 200 in.)
- X = Special null and/or dead space

TRANSDUCER CABLE DRIVER (Analog Only)
- 0 = No. ≤ 100 ft signal cable from transducer - (Standard for all digital systems)
- 1 = Yes. > 100 ft signal cable from transducer - (Standard for intrinsically safe)

HEAD ELECTRONICS TEMPERATURE RANGE
- 1 = -40°F to +180°F (Standard for strokes greater than 12 in., positive pulse)
- 2 = -40°F to +180°F (New standard for strokes up to 12 in.)
- X = Special temp. range and/or electronics

ENVIRONMENTAL
- 0 = NEMA 1, dust tight (Standard)
- 3 = Intrinsically safe - 6 wire
- 4 = NEMA 6, hermetically sealed
- 5 = NEMA 4, splash proof (Standard with Style 02)
- X = Special

TRANSDUCER CABLE
- 0 = 5 ft with connector - analog (Style 01, 03)
- 1 = 2 ft with connector - digital (Style 01, 03, former std)
- 2 = None - analog (Style 02)
- 3 = None - digital (Style 02)
- 6 = 5 ft pigtails - analog
- 7 = 5 ft pigtails - digital
- 8 = 5 ft with connector - digital (new std.)
- 9 = Other length or connector

Digital Interface Box (DIB)

Model Number

TRANSDUCER
First 8 digits of transducer code

STYLE
- 40 = ± 15 Vdc and + 35°F to + 150°F - (Standard)
- 41 = ± 15 Vdc and - 40°F to 180°F
- 42 = Universal ± 15 VDC
- 43 = ± 12 Vdc and + 35°F to 150°F
- 44 = ± 12 Vdc and - 40°F to + 180°F
- 45 = Interface PCB
- 46 = Universal Interface PCB
- XX = Special

MAXIMUM UPDATE TIME MSEC
- 0 = 1.5
- 1 = 2.5
- 2 = 3.0
- 3 = 3.5
- 4 = 5.0
- 5 = 7.5
- 6 = 10.0
- 7 = 15.0
- 8 = 25.0
- X = None-Other

INTERROGATION
- 0 = Internal - (Standard)
- 1 = External

RECIRCULATIONS
- 0 = 1
- 1 = 2
- 2 = 4
- 3 = 8
- 4 = 16
- 5 = 32
- 6 = 64
- 7 = 128

ENVIRONMENTAL
- 0 = Standard
- 1 = Splash Resistant
- 2 = Conformal Coat

Digital Counter Card - Series 60

Model Number

TRANSDUCER
First 8 digits of transducer code

OUTPUT FORMAT
- 60 = Natural binary - 12 bits
- 61 = Natural binary - 13 bits
- 62 = Natural binary - 14 bits
- 63 = Natural binary - 15 bits
- 64 = Natural binary - 16 bits
- 65 = Natural binary - 17 bits
- 66 = Natural binary - 18 bits
- 67 = Natural binary - 19 bits (two cards required)
- 6X = Natural binary (MTS to complete code)
- 70 = BCD 3 digits (12 bits)
- 71 = BCD 3.5 digits (14 bits)
- 72 = BCD 4 digits (16 bits) (two cards required)
- 73 = BCD 4.5 digits (18 bits) (two cards required)
- 74 = BCD 5 digits (20 bits) (two cards required)
- 7X = BCD (MTS to complete code)
- XX = Other (Consult MTS Sensors Division)

ORIENTATION
- 0 = Forward count - (Standard)
- 1 = Reverse count

DATA VALIDATION
- 0 = 1 Microsecond latch pulse - (Standard)
- 1 = 12 Microsecond latch pulse
- 2 = Latch inhibit input
- X = Special (Consult MTS Sensors Division)

RESOLUTION (SCALED)
- 0 = 0.1 in. (2.5 mm)
- 1 = 0.01 in. (0.25 mm)
- 2 = 0.004 in. (0.1 mm)
- 3 = 0.002 in. (0.05 mm)
- 4 = 0.001 in. (0.025 mm)
- 5 = 0.0005 in. (0.0125 mm)
- 6 = 0.00025 in. (0.0063 mm)
- X = Other (Consult MTS Sensors Division)

Digital Counter Card - Series 80

Model Number

TRANSDUCER

First 8 digits of transducer code

OUTPUT FORMAT

80 = Natural binary parallel transmission (12 bits)
81 = Natural binary parallel transmission (13 bits)
82 = Natural binary parallel transmission (14 bits)
83 = Natural binary parallel transmission (15 bits)
84 = Natural binary parallel transmission (16 bits)
85 = Natural binary parallel transmission (17 bits)
86 = Natural binary parallel transmission (18 bits)
87 = Natural binary parallel transmission (19 bits)
8X = Natural binary (Ask MTS to complete code)
89 = Natural binary, other than above

90 = BCD 3 digits 12 bits (999 max reading)
91 = BCD 3-1/2 digits 14 bits (3999 max reading)
92 = BCD 4 digits 16 bits (9999 max reading)
93 = BCD 4-1/4 digits 17 bits (19999 max reading)
94 = BCD 4-1/2 digits 18 bits (39999 max reading)
95 = BCD 5 digits 20 bits (99999 max reading)
9X = BCD (Ask MTS to complete code)
99 = BCD, other than above

ORIENTATION

0 = Forward count - (Standard)
1 = Reverse count

DATA VALIDATION

0 = 1 Microsecond latch pulse and latch inhibit input (Standard)
1 = 12 Microsecond latch pulse and latch inhibit input
X = Other, or speciall (Consult MTS Sensors Division)

RESOLUTION (SCALED)

0 = 0.1 in. (2.5 mm for metric strokes)
1 = 0.01 in. (0.25 mm for metric strokes)
2 = 0.004 in. (0.1 mm for metric strokes)
3 = 0.002 in. (0.05 mm for metric strokes)
4 = 0.001 in (0.025 mm for metric strokes)
5 = 0.0005 in (0.0125 mm for metric strokes)
6 = 0.00025 in. (0.0063 mm for metric strokes)
9 = Other or unscaled (Consult MTS Sensors Division) and specify resolution separately

New Features and Design Changes

- Zero preset by DIP switches - can be reset in the field if desired
- Latch inhibit offered as standard at no charge (pin 24)
- Latch pulse now offered on pin 3 (formerly on pin 24)
- Millimeter resolution is now standard for strokes specified in millimeters
- Card width now 4-1/2 in. (formerly 4-1 4 in.)

Section I
Introduction

Product Improvements

This edition of the Installation and Instruction Manual covers both Series 60 Digital Counter Cards (the older version) and Series 80 Digital Counter Cards (released in June 1988). Before installation, you must determine which type of card you are using in your application. Use the following table to identify your card:

Type	Series 60 (former)	Series 80 (June 1988)
Width	4-1/4 in.	4-1/2 in.
Color	Tan	Green
Zero preset	by fixed jumpers in U5	by DIP switches S1 and S2

Both versions have the same pattern of mounting holes for surface mounting, and both are rack-mountable.

Notice also that Digital Interface Boxes shipped after March 1, 1988 are supplied with the capability for driving a transducer cable up to 100 feet long. Refer to Section 3 for cable recommendations.

The Temposonics brand Linear Displacement Measurement System measures the position of a external magnet to a high degree of precision. The system measures the time interval between an interrogation pulse and a return pulse. The interrogation pulse is transmitted to the transducer. The return pulse is created by the magnet, which is located at the position to be measured. The time difference between pulses is converted to a natural binary or BCD direct digital output signal.

The direct digital output system components include a linear displacement transducer (LDT), a digital interface box (DIB), and a digital counter card. When supplied as a scaled system, these system components are matched and factory calibrated to provide an exact, discrete resolution.

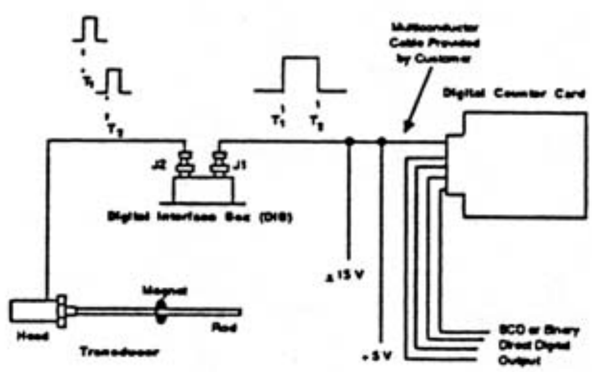


Figure 1-1. Linear Displacement Measurement System Functional Description

Temposonics normally supplies a "full digital" system, consisting of all three system components. If the counter card function is performed in a digital computer, programmable controller, or motion controller (such as the MTS Motion Plus™ TDC series controller), a "half digital" system is often supplied. The half digital system consists of the LDT and digital interface electronics only, with system variables factory set to customer specifications.

1.1 Transducer (LDT)

The interrogation pulse travels the length of the transducer by a conducting wire threaded through the hollow waveguide. The waveguide is spring loaded within the transducer rod and exhibits the physical property of magnetostriction. When the magnetic field of the interrogating pulse interracts with the stationary magnetic field of the external magnet, a torsional strain pulse or "twist" is produced in the waveguide. This strain pulse travels in both directions, away from the magnet. At the end of the rod, the strain pulse is damped within the "dead zone" (5 to 7 inches in length). At the head of the transducer, two magnetically coupled sensing coils are attached to strain sensitive tapes. The tapes translate the strain pulse through coils to an electrical "return pulse". The coil voltage is then amplified in the head electronics before it is sent back to the interface box as the conditioned "return pulse".

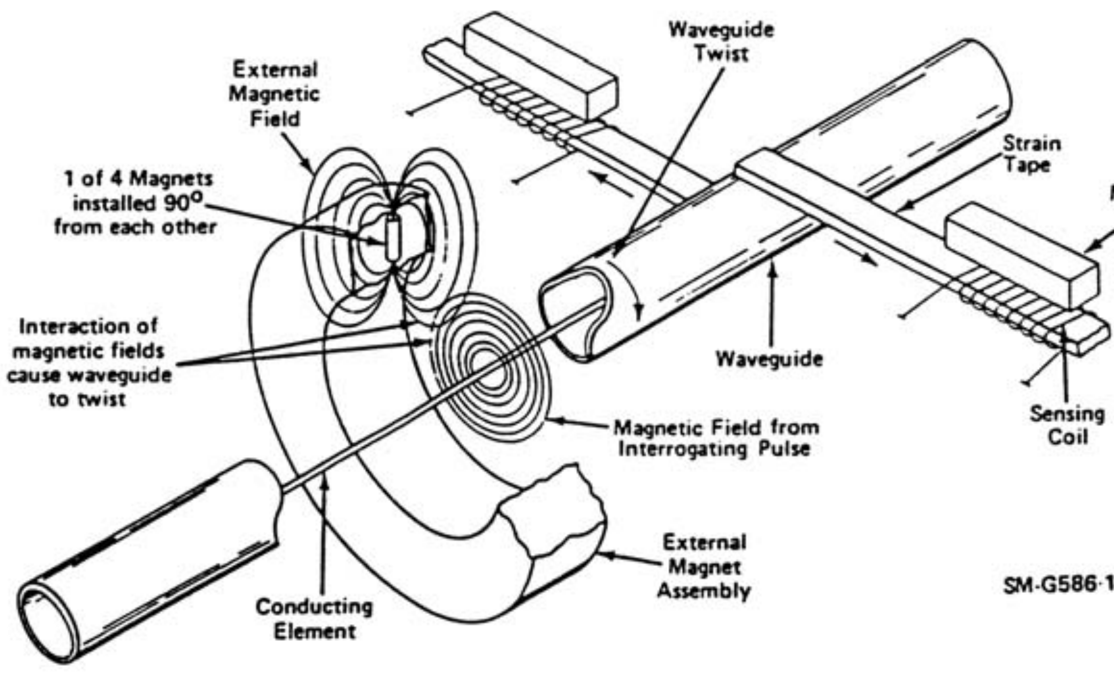


Figure 1-2. Waveguide Interaction

1.2 Digital Interface Box (DIB)

The digital interface box (DIB) (optionally available as a card) contains the intelligence for interrogation and return pulse sensing of the transducer.

The interrogation frequency is factory determined to allow sufficient time for return pulse sensing based upon the transducer stroke and optional recirculations. The frequency of interrogation is controlled by a 555 integrated circuit timer and the required R-C network for the desired time constant. Optionally, an external interrogation pulse input is provided on J-2 for user interrogation and synchronization with the selected receiver device. (Consult MTS Sensors Division for application notes.)

The interrogating pulse turns on a flip-flop, which stays on until the return pulse switches the signal off. The time "length" of the signal is directly proportional to magnet position, and after buffering within the box, the pulse is sent to the counter card as the pulse duration signal (refer to Figure 1-1).

NOTE

> The pulse duration output signal is absolute and should not be confused with frequency or "pulse train" type signals, such as provided with encoders. Pulse counting techniques cannot be used.

Most digital interface boxes use a technique termed "recirculations" to improve system resolution. The recirculation number (2, 4, 8, 16, 32, etc) is factory set within the electronics to provide a pulse duration signal multiplier equal to the number of recirculations. The technique uses return pulses to trigger additional interrogation pulses. The number of "recirculation pulses" is determined at the time of order and should not be changed without factory consultation.

1.3 Digital Counter Card

The digital counter card measures the on-time of the interface box pulse duration signal. This is accomplished by using a crystal oscillator with frequency selected to provide the desired resolution (counts per inch).

The leading edge of the pulse duration signal enables the counter registers, and the trailing edge triggers a "latch pulse" to download the count into the output registers. The latch pulse is normally available for the receiver device to interpret as a "data valid" signal; normally low = **data valid**, TTL level high = **data invalid.** The latch pulse frequency is the same as the interrogation frequency, and the duration is nominally 1 microsecond. Refer to Figure 3-5.

Scaling of the counter card is accomplished by matching the counter card crystal frequency to the gradient of the transducer to provide 0.001 inch, 0.0005 inch, etc, per count. Unscaled systems may require scaling within the receiver device, depending upon desired accuracy.

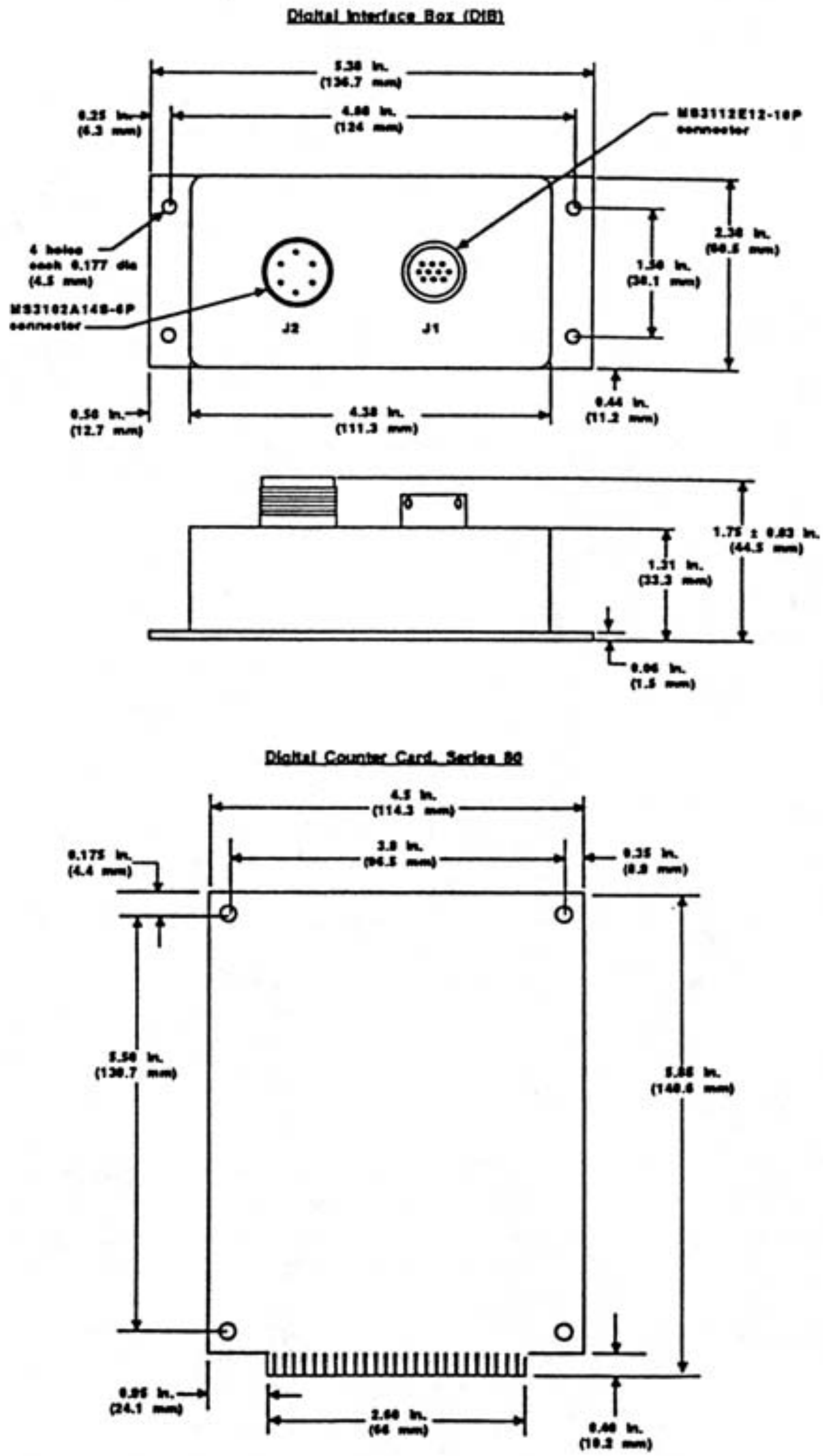


Figure 1-3. Digital Electronics

1.3.1 Scaling

In most cases, the system supplied is a scaled system. Scaling refers to the selection of system component variables so that the natural binary output represents a discrete number of inches per count, such as 0.002 inch, 0.001 inch, or 0.0005 inch per count. For BCD outputs, scaling means that the output reads directly inches (mm, etc), and need not be corrected mathematically.

The system variables that are matched include the transducer stroke, the number of recirculations, the null point, and the counter card crystal oscillator clock. The transducer, interface box and counter card are factory calibrated to provide the desired resolution. The counter card crystal frequency is calculated based upon the transducer velocity gradient, which is unique to the transducer serial number. The zero pre-set is factory set on the counter card, and is also matched to the transducer. To maintain a scaled output, the user should use a transducer and counter card with the same serial number. Substitution of interface boxes of the same stroke and recirculation number does not affect the output reading.

An unscaled system is provided upon request. An unscaled system may require calibration (refer to Subsection 3.4) to mathematically correct the digital output to read in inches, millimeters, etc. The scale factor for unscaled systems is not a discrete number of inches per count, but should be within ±0.2% of the specified resolution for 27-28 MHz systems. For example, an unscaled system specified for 0.001 inches per count may have a scale factor of 0.001002 inches per count (approximately). Similarly, an unscaled BCD output may have a scale factor of 1.002 inches per inch of reading.

Interchanging system components which do not have the same serial number will also result in an unscaled output. Refer to troubleshooting (Subsection 4.4) and Subsection 1.3.3 below.

1.3.2 "Universal" Interface Box or Card

Universal boxes (or cards) are supplied to certain customers upon request. In a universal box, the DIB interrogation pulse timing is set for a certain maximum stroke length, typically from 60 to 72 inches. The box will interrogate at the maximum stroke frequency, but can be used with any transducer with stroke length greater than 12 inches and up to the maximum. (Transducers with ≤ 12 inches are normally negative pulse interrogation and require a pulse change modification within the DIB.) The recirculation setting is also factory set, and will provide published resolution with the proper recirculation number.

The only performance change is that the update time will be that for the maximum stroke length of the interface box (refer to general bulletins). Also note that a small zero shift may occur when used with transducers of different stroke length.

1.3.3 "Universal" Counter Card

A universal counter card differs from a scaled counter card in two ways:

1. The crystal is selected based upon an "average" transducer gradient.

2. The zero pre-setting is selected using a randomly selected transducer with an "average" gradient.

The averaging results in a scale factor within ±0.6% of the specified nominal resolution. The zero position will also be affected, but should be within ±0.1 inches of the specified null position.

To correct for scale and zero offset, refer to Subsection 3.4, System Calibration.

Also note that if a randomly selected counter card is used with a transducer, the system will perform as a "universal" counter card system.

1.3.4 System Component Changes

The following general rules apply when interchanging system components or ordering spare parts:

1. Use system components with matched serial numbers whenever possible.

2. Use the crystal (Y1 or U4 on the counter card) with the transducer that is matched to it.

3. Use the zero pre-set (U5 on the counter card) with the transducer and crystal that is matched to it. (The zero pre-set is a removable 18 pin jumpered DIP socket on Series 60 cards, or two DIP switches on Series 80 cards.)

4. Whenever system components are not matched, or a non-matched crystal (or counter card) is used, a system calibration (refer to Subsection 3.4) should be performed.

5. If interface boxes are interchanged, it is preferable that they be of the same stroke and recirculation setting (refer to Subsection 1.3.2).

1.3.5 Spare Parts and Inventory Considerations

If ordering a spare transducer, a matched crystal and zero pre-set should be ordered (for Series 60 cards only) to avoid system calibration upon replacement. For Series 80 cards, the zero can be set using DIP switches.

A universal type spare interface box or counter card can be used as a common spare. However, a system calibration should be performed after any system component change.

1.3.6 Receiver Electronics without Scaling Feature

Use of the Temposonics Linear Displacement Measurement system with receiver electronics which does not permit field scaling requires special application considerations. A mechanical means of zero-positioning of the magnet must be designed into the installation, and a unit with scaled output must be used.

1.4 Specifications

Parameter	Specification
Supply Requirements	± 15 Vdc & + 5 Vdc, ± 5%, 1% ripple max. + 15 V at 100 mA − 15 V at 75 mA + 5 V at 1.2 amps (400 mA for DIB; 800 mA counter card)
Electrical Stroke	As specified. Up to 360 inch available
Null Position	Fixed, 2 inches from hex (standard), or as specified
Dead Space	Fixed, 5 or 7 inches from end of rod, as specified
Non-Linearity	± 0.05% full stroke, maximum
Repeatability	Better than ± 0.001% (0.0001 inch minimum)
Hysteresis	0.0008 inch maximum
Temperature Coefficient	0.00018 inch/°F (0.00011 inch for ≤ 12 inches stroke) + 3ppm/°F/ inch stroke - transducer. 5ppm/°F nominal for external electronics
Operating Temperature	− 40 to + 180°F transducer rod + 35 to + 150°F head electronics (≤ 12 inches)* − 40 to + 180°F head electronics (> 12 inches) + 35 to + 150°F digital interface box
Output	TTL compatible, nominal 0 & 5 Vdc, parallel, true high. Source Current: 0.8 mA Sink Current: 16 mA
Operating Pressure	Rated by Factory Mutual for 3000 psi (20.68 MPa) operating pressure, and 8000 psi (55 MPa) peak pressure.
Adjustments	None

*Units shipped after 6-1-88 are suitable for − 40 to + 180°F regardless of stroke.

Specifications are subject to change without notice. Contact MTS for verification of specifications critical to your needs.

Section II
Service

2.1 General

The Temposonics Brand Linear Displacement Measurement System does not require service under normal use. The system is non-contacting, solid state, and performance does not degrade, age or drift over time.

Digital systems have a zero adjustment only. They do not have any field adjustments for scale purposes. The output is factory set during final calibration by selection of the counter card crystal frequency and zero pre-set. If a system configuration change requires a new resolution, the system must be returned to the factory to perform the changes. Alternatively, receiver device software may be reprogrammed to adjust to the new settings in some cases.

If a system performance check is desired, use the calibration procedure in Subsection 3.4.

Section III
Installation

This section describes general installation procedures for the Digital Linear Displacement Transducer measurement system. Specific installation procedures depend on the application. The installation involves environmental considerations, mechanical installation and electronic connections.

3.1 Environmental Considerations

The location of components is determined by the application requirements. The following describe the environments suitable for the component configuration. Ensure the components can withstand the environment where they will be installed.

- A transducer assembly with a blue dust cover over the LDT head is suitable for general purpose applications located indoors.
- A transducer assembly with a ruggedized LDT head cover is suitable for environments exposed to moisture, vibration and outdoor elements.
- The digital interface box must be protected from moisture and vibration.
- The digital counter card is suitable for non-hazardous, environmentally-controlled atmospheres only, such as control rooms or control panels indoors.
- A transducer assembly with the intrinsically safe design (approved for Class I, Division 1, Groups C and D) is available for hazardous areas.

NOTE

The **intrinsically safe** design has special installation requirements which are not covered in this manual. Consult MTS Sensors Division for details.

3.2.1 Mechanical Installation

The mechanical installation includes mounting the transducer, the counter card, electronics box and the permanent magnet. Before installing the transducer assembly, it is necessary to know the null position, stroke length, full-scale position and the dead zone (refer to Figure 3-1).

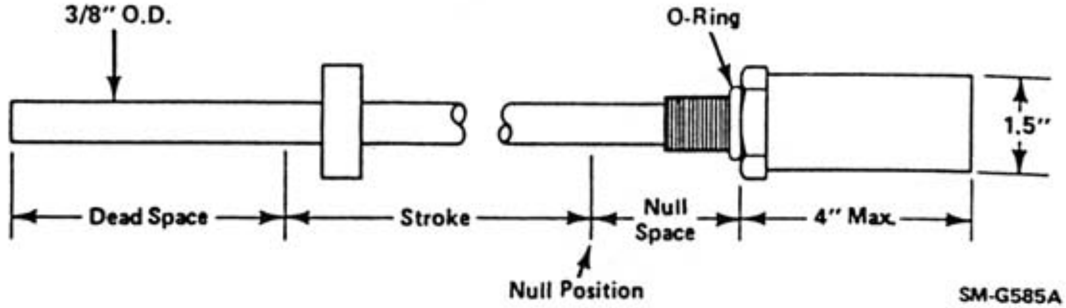


Figure 3-1. LDT Assembly

Take the following steps to install the LDT measurement system:

1. The transducer assembly is mounted to the selected location using the 3/4 inches (19 mm), 16 UNF thread of the transducer. Allow sufficient area to access the hex head to tighten the transducer assembly. Install an O-ring (type MS28778-8 is recommended) in the special groove if a pressure or moisture seal is required.

2. Install the permanent magnet over the LDT rod. The permanent magnet is mounted to the movable device from which displacement is to be measured. To minimize the effect of ferromagnetic materials (such as iron, nickel, steel, etc) on the magnetic field of the permanent magnet, ensure the minimum spacing requirements are met as shown in Figure 3-2. Any non-magnetic materials can be in direct contact with the permanent magnet. Types of magnets are shown in Figure 3-3.

NOTE

Clearance between the magnet and the LDT rod is not critical. However, contact between the components will cause wear over time. The installation of supports or readjustment of the supports is recommended if the magnet contacts the LDT rod.

3. Move the permanent magnet full-scale to determine if support brackets are required. If the magnet contacts the LDT, mount a support bracket to the end of the LDT. Long transducers may need additional supports to be attached to the transducer rod. Refer to Subsection 3.2.2 for the procedure for installing transducer supports.

4. Mount the digital interface box in a location within reach of the LDT assembly cable. Older systems allow the digital interface box to be mounted within 2 feet of the LDT assembly; systems supplied after 3-1-88, within 100 feet.

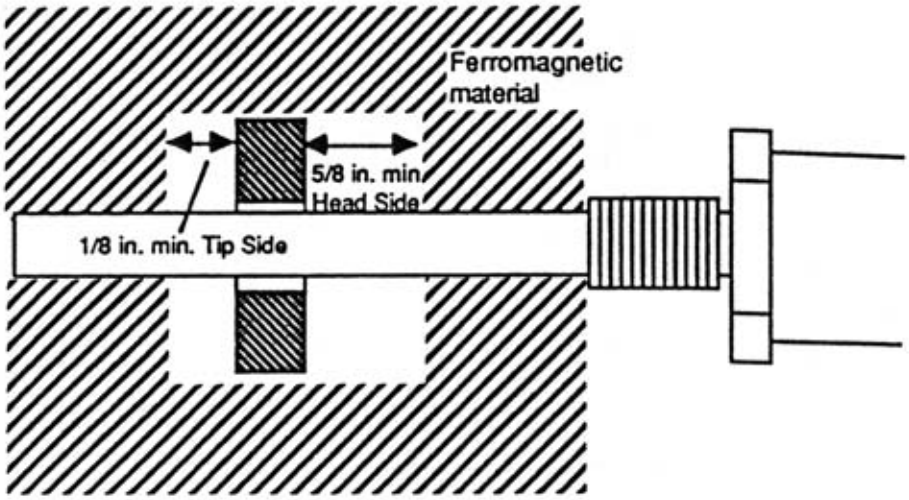


Figure 3-2. Ferromagnetic Material Mounting Specifications

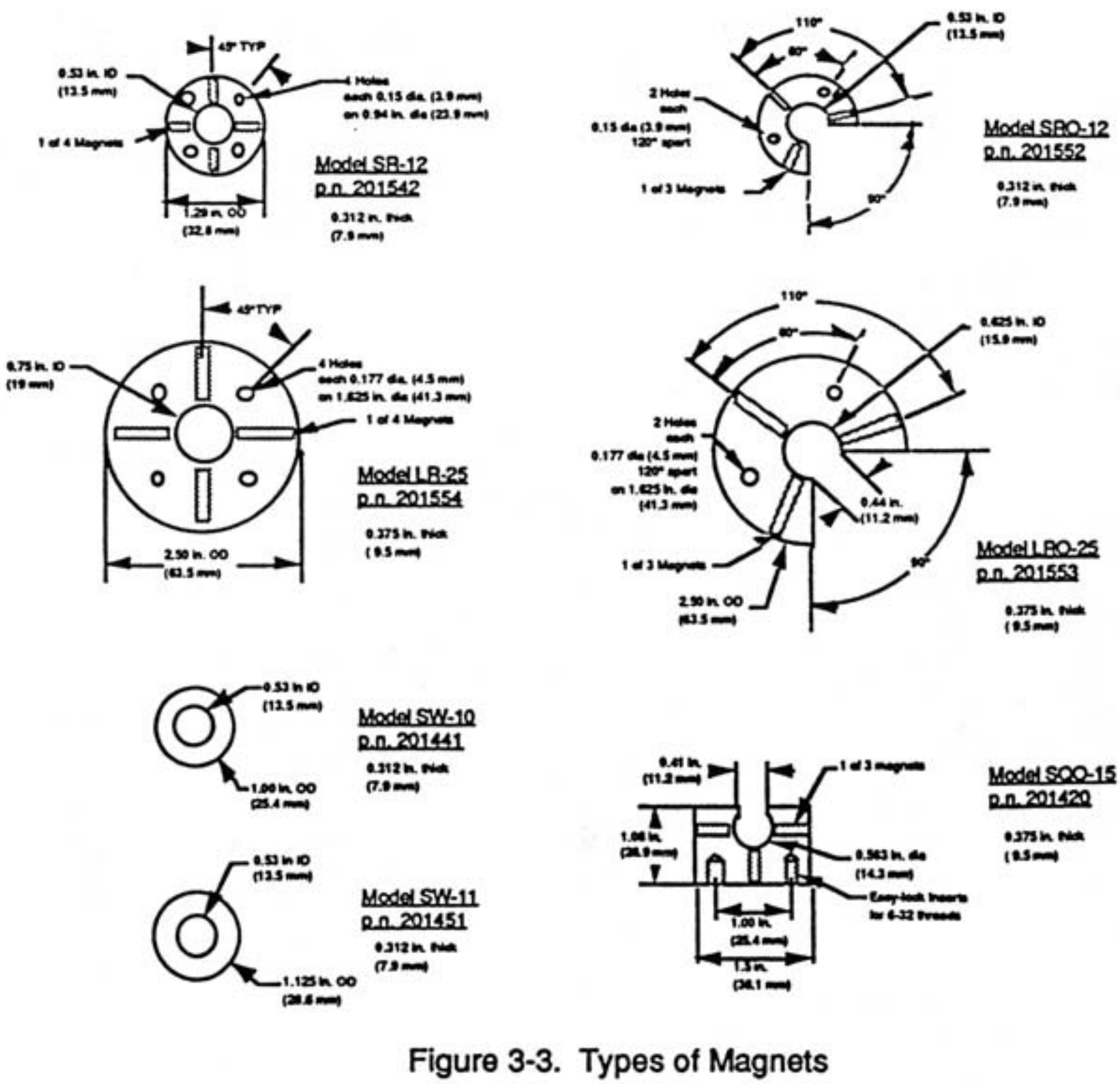


Figure 3-3. Types of Magnets

6. Mount the digital counter card within 300 feet* of the interface box. The card may be mounted in a standard card cage, or can be surface mounted using standoffs. Allow at least one inch on each side of the counter card for proper spacing. It is best to mount the card so that the edge connector is accessible for signal level testing.

NOTE

The counter is matched to the transducer by serial number. Do not interchange counter cards (refer to System Component Matching).

*Consult MTS Sensors Division for longer distances.

3.2.2 Types of Transducer Supports

Long transducers (more than 4 feet long) may require supports to maintain proper alignment between the transducer rod and the permanent magnet. All flexible transducers require supports to maintain the design shape. When transducer rod supports are used, special permanent magnets are required.

Transducer supports attached to the active stroke length must be made of non-ferrous material with a gage thickness which will permit the permanent magnet to pass without obstruction. Transducer supports connected to the dead zone can be any type of material since the permanent magnet should not enter that area. The following are descriptions of several types of transducer supports.

Loop Type Support

Loop type supports are recommended for straight transducers and are also used with channel supports. Loop type supports must be thin enough to permit free movement of the magnet. Figure 3-5 illustrates the fabrication of a loop type support. Figure 3-6 illustrates a typical channel support.

NOTE

When open magnets are used, ensure the transducer rod remains within the inside diameter of the magnet throughout the length of the stroke. If the transducer rod is allowed to leave this zone and enter the cut-out area of an open magnet, the transducer signal will be lost. Figure 3-4 shows correct and incorrect transducer rod positions.

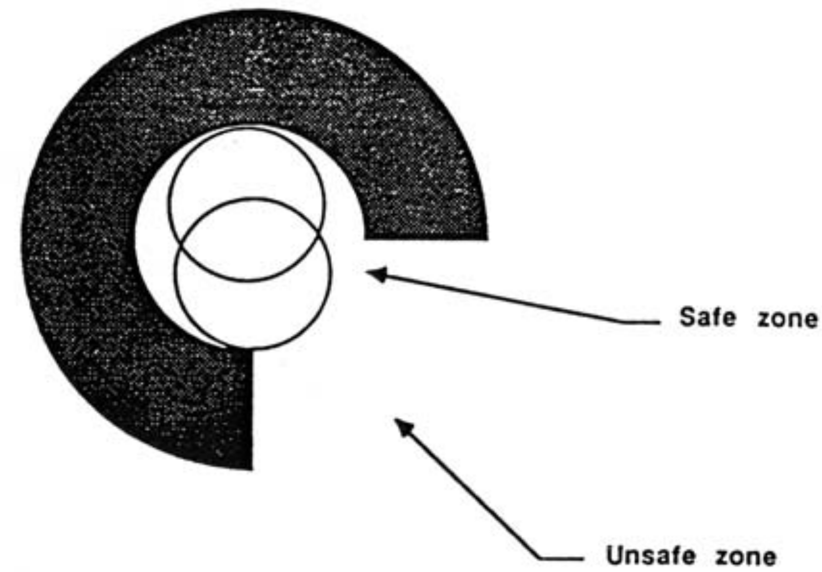


Figure 3-4. Transducer Rod Positions within an Open Magnet

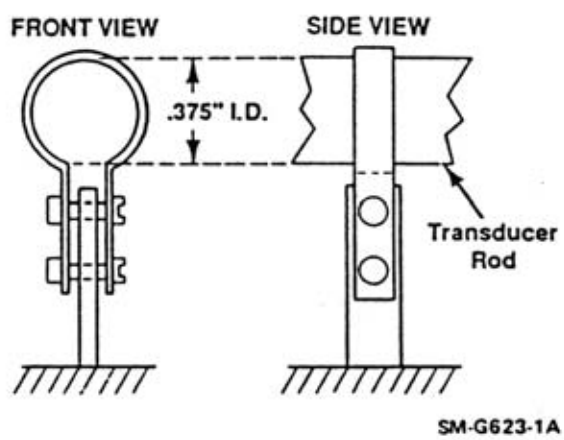


Figure 3-5. Loop Support

Channel Type Support

Channel type supports are typically straight. Loop supports are normally required to keep the transducer within the channel. Figure 3-6 illustrates the channel support. Channel supports are available from various manufacturers ("linear ways") or may be fabricated.

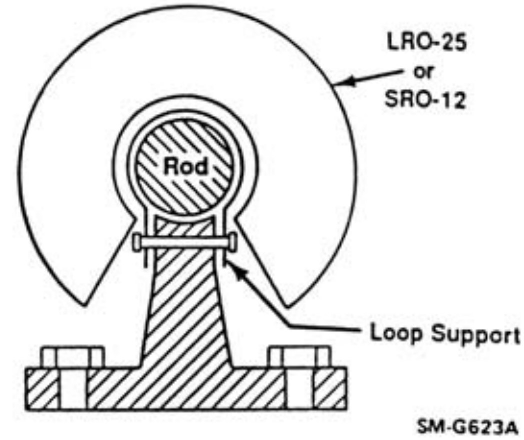


Figure 3-6. Channel Support

Guide Pipe Supports

Guide pipe supports are sections of thin-walled pipe, normally used to support flexible transducers. A guide pipe support is constructed of non-ferrous material to maintain the desired shape. The transducer rod is installed into the pipe, therefore, the inside diameter of the pipe must allow proper clearance to install the rod and the outside diameter must allow for magnet clearance. Refer to the pipe manufacturer's specifications and dimensions (schedule 10, 40, etc) to select pipe in accordance with transducer and magnet specifications and dimensions. Guide pipe is typically supported at each end of the pipe. Figure 3-7 illustrates a guide pipe support.

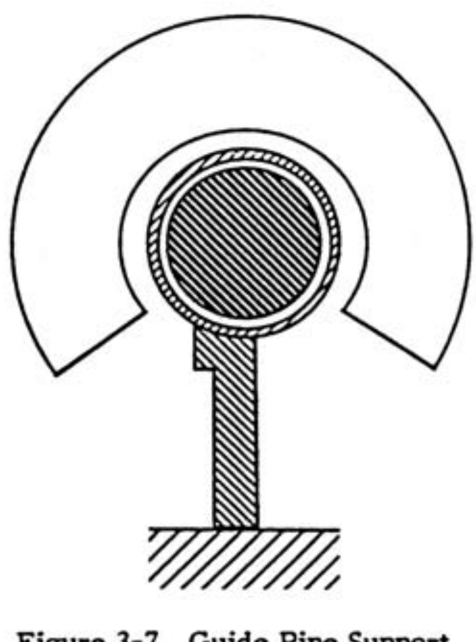


Figure 3-7. Guide Pipe Support

Spring Loading or Tensioning

The transducer rod (flexible or rigid) can be spring loaded or tensioned using a stationary weight. Attach a spring mechanism or weight to the dead zone of the transducer rod with a clamping device which will not deform the transducer rod. The maximum weight or spring tension is 5 to 7 lbs. Spring loading or tensioning is recommended for installations that do not permit loop type supports and are subject to vibration or abuse.

3.2.3 Flexible Transducer Installation

This subsection provides the installation procedure for flexible transducers. It is necessary to know the null position, stroke length, full-scale position and the dead zone to install the transducer (refer to Figure 3-1). Before installing the flexible transducer, review the following considerations:

- All flexible transducers are custom manufactured for a specific application and installation. The specific requirements are determined prior to ordering, which includes specific curvatures and straight sections at specific distances from the transducer head.

- Flexible transducers should not be subjected to temperatures above 130°F (54°C) unless specified. The temperature of the transducer rod should not vary more than ±30°F (±16°C) unless specified.

- Flexible transducers should not be subjected to pressures above atmospheric pressure.

- Flexible transducers can be flexed or curved to a minimum diameter of 36 in. (91 cm) during installation.

- Flexible transducers require supports or anchoring to maintain the designed shape. Refer to Subsection 3.2.2 for information to install transducer supports.

- Some long transducers are ordered as flexible units to facilitate shipping and handling only, even though they are used for straight applications.

CAUTION

DO NOT attempt to install a flexible transducer without knowledge of the design installation dimensions. Failure to follow the design dimensions can result in improper operation or transducer damage.

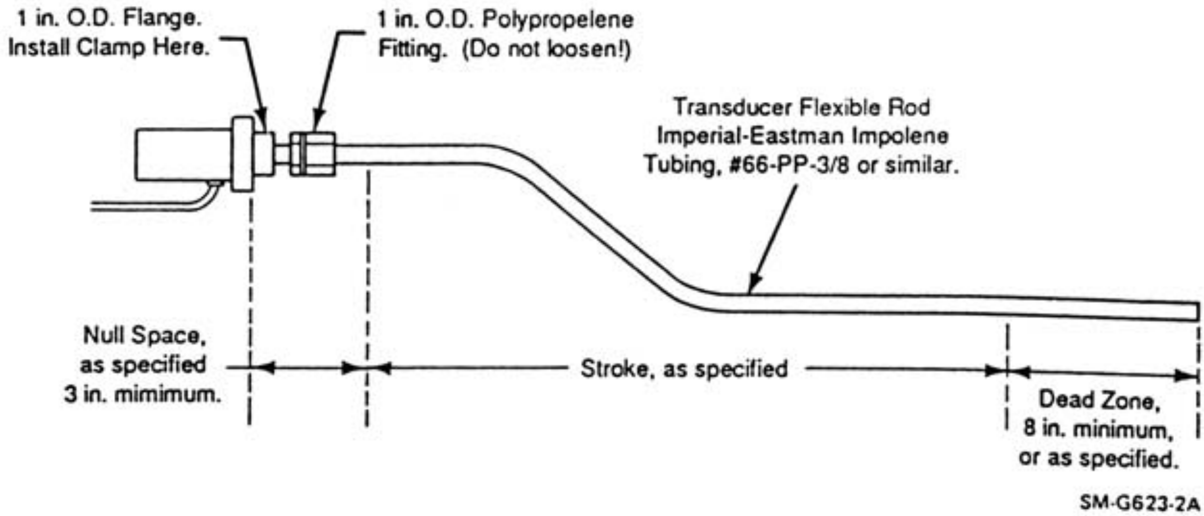


Figure 3-8. Flexible Transducer

Take the following steps to install a flexible transducer:

CAUTION

DO NOT loosen or mount the transducer using the polypropylene fitting near the transducer head. This will cause damage to the transducer.

1. Transducers supplied with a 1 inch O. D. head flange require a U-bolt, flange collar or similar clamping device to keep the transducer head stationary.

   Transducers with a threaded hex can be mounted using the threads. If the transducer must be rotated to engage the threads, ensure the flexible rod can rotate freely. If the rod binds or cannot be rotated, a bracket or threaded flange should be used (hold the transducer stationary and rotate the bracket or flange to engage the threads).

2. Install the permanent magnet over the LDT rod. The permanent magnet is mounted to the movable device from which displacement is to be measured. To minimize the effect of magnetic materials on the magnetic field of the permanent magnet, ensure the minimum spacing requirements are met as shown in Figure 3-2. Only nonmagnetic materials can be in direct contact with the permanent magnet.

3. Mount the digital interface box in a location within reach of the LDT cable. Older systems allow the box to be mounted within 2 feet of the LDT assembly. Newer systems with buffer driver allow the interface box to be mounted within 100 feet of the LDT assembly. All units after 3-1-88 have this driver.

4. Refer to Subsection 3.2.2 for information to install transducer supports.

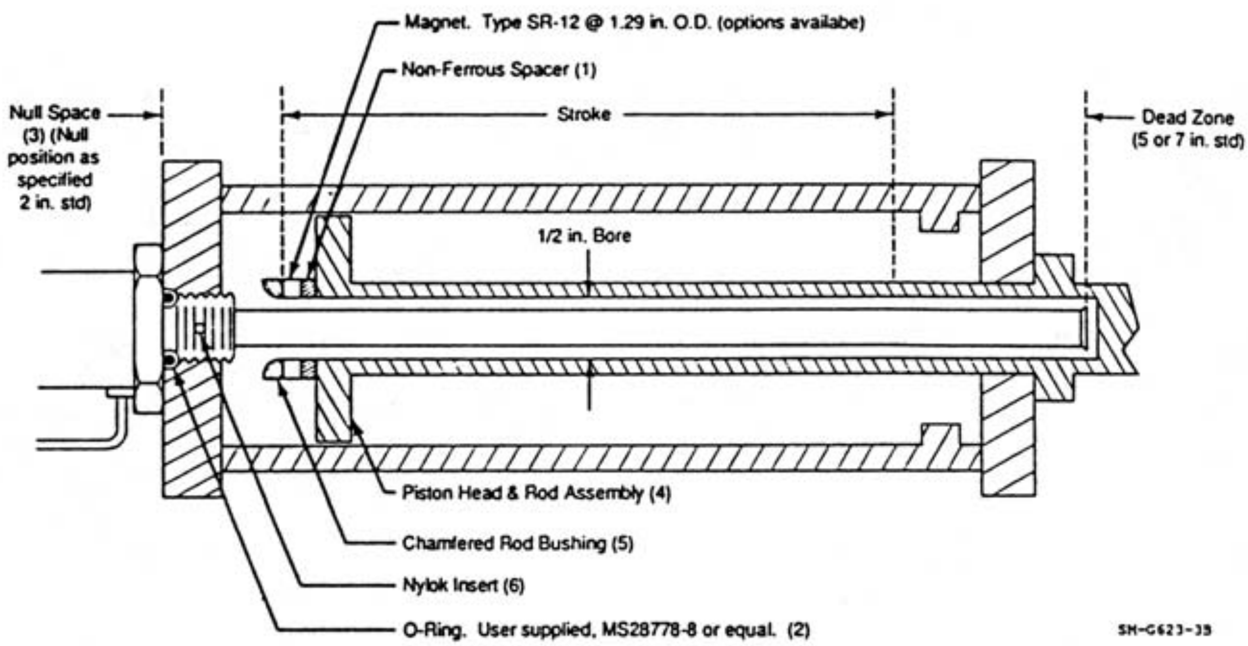


Figure 3-9. Typical Cylinder Installation, Piston at Full Retraction

3.2.4 Cylinder Installation

This subsection provides information for cylinder applications. The rigid transducer installation procedure can be used as a guide for cylinder installations. Figure 3-9 shows a typical cylinder installation. Review the following before attempting a cylinder installation.

1. Use a non-ferrous (plastic, brass, teflon, etc) spacer to provide 1/8 inch (32 mm) minimum space between the magnet and the piston.

2. An O-ring groove is provided at the base of the transducer hex head for pressure sealing. Temposonics uses MIL-standard MS33514 for the O-ring groove. Refer to MIL-standard MS33649, (or SAE J514) for machining of mating surfaces. Use O-ring number MS28778-8 or equal.

3. The null space is customer specified at full retraction according to the installation design and cylinder dimensions. Ensure the magnet can be mounted at the proper null position.

4. The piston head shown in Figure 3-9 is typical. For some installations, depending on the clearances, it may be desired to countersink the magnet.

5. A chamfered rod bushing should be considered for strokes over 5 feet (1.5 meters) to prevent wear on the magnet as the piston retracts. The bushing should be made from teflon or similar material.

6. A nylok self locking insert is provided on the transducer threads. An O-ring groove is provided at the base of the transducer hex head for pressure sealing.

7. The recommended bore for the cylinder rod is 1/2 inch (13 mm). The transducer rod includes a 0.44 inch (12 mm) end plug; a flush end plug is available. Use standard industry practices for machining and mounting of all components. Consult the cylinder manufacturer for applicable SAE or MIL-specs.

CAUTION

DO NOT attempt to loosen the end plug on the transducer. If this plug is loosened or removed, reseal it with Loctite and torque the plug until it is properly seated against the end of the pipe.

3.3 Electronic Connections - General

Electronic connections are made at connectors J2 and J1 of the interface box (DIB) and at pins 1 to 25 of the counter card edge connector.

To ensure system performance to published specifications, wiring procedures and selection rules must be carefully followed.

The following recommendations are supplied for "full digital" systems, which include a Temposonics brand digital counter card. For systems which use a digital counting device in the receiver computer (such as MTS Motion Plus control systems), the counter card is not supplied. Use the following procedures in conjunction with the receiver device manufacturer's recommendations.

3.3.1 Transducer Connections

The LDT is supplied with 5 feet (standard) of integral cable. Ruggedized head designs are supplied with an extension cable. It is recommended to keep the transducer cable as short as possible to avoid possible noise or temperature effects on accuracy.

If an extension cable is required, the following guidelines must be followed:

NEMA 1 (blue cover) transducers

If supplied with 2 feet of integral cable (systems prior to 3-1-88), then, unless extension cable is specified, the digital interface box has not been modified to buffer pulse transmissions. Do not attempt to extend the cable without factory modifications to the interface box.

If supplied with 5 feet or more of integral cable (systems after 3-1-88), the interface box has been modified for pulse buffering, and extension cable can be used as described below.

NEMA 4 and 6 Ruggedized Transducers

All ruggedized transducers require an extension cable with mating connection, supplied by MTS Sensors or by the buyer. If the factory-supplied cable is 5 feet or longer, the interface box has been modified for 100 foot drive capability, and you may use a cable up to 100 feet long.

If the cable supplied is less than 5 feet long, do not attempt to extend the cable further.

Extension Cable

The extension cable is fabricated from Belden number 9931, 9730, or optionally, Belden 83506 teflon covered cable. Substitutes are not acceptable.

The maximum cable length is 100 feet. Construct the extension cable using the color codes shown in Table 3-1, or order from MTS Sensors Division.

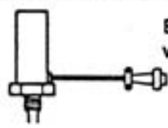
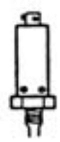
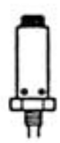
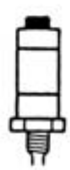
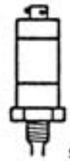
Table 3-1. J2 Connections

J2 Signal/Function	J2 Pin	Wire Color Code: Integral Cable or Belden 9931 83506 Extension Cables	Wire Color Code: Belden 9730 wire/shield
+ 12 to + 14.5 Vdc	A	Green	Black/Blue
DC Common/Ground	B	Black	Black/Red
Return pulse from transducer	C	Brown or Orange	Green/Blue
− 13.5 to − 14.5 Vdc	D	Blue	Black/Green
Interrogation pulse to transducer	E	White	White/Green
11.5 to + 12 Vdc	F	Red	Red/Red
Cable Ground*	–	SHIELD – see below	SHIELD – see below

* Cable Grounds:

1. Cable shields are grounded at one end of cable only.
2. Integral cable shield is connected to circuit ground within transducer head.
3. Extension cable shield should be connected to ground at the electronics box connector only. Apply ground by separate connection to earth ground or by connecting to pin B on the connector which mates to the box.

Table 3-2. J2 Mating Connectors

Transducer Head Connector	Transducer Head Design	Mating Connectors: To Transducer Head	Mating Connectors: To Interface Box
MS 3106A-14S-6S MS 3106E-14S-6S (environmental)	 Blue Cover w/integral cable (NEMA 1)	MS 3101A-14S-6P MS 3101E-14S-6P (environmental)	MS 3106A-14S-6S MS 3106E-14S-6S (environmental)
MS 3113H-10-6P (DT1H-10-6PN)	 SRH/Hermetically Sealed (NEMA 6)	MS 3116F10-6S (environmental)	MS 3106A-14S-6S MS 3106E-14S-6S (environmental)
MS 3102E-14S-6P	 SRH/Environmental (NEMA 4)	MS 3106E-14S6S (environmental)	MS3106A-14S-6S MS 3106B-14S-6S (environmental)
MS 3100F-14S-6P	 Ruggedized/ Environmental (Woodit)	MS 3106E-14S-6S (environmental)	MS 3106A-14S-6S MS 3106E-14S-6S (environmental)
MS 3113H-10-6P (DT1H-10-6PN)	 Ruggedized/ Hermetically Sealed (Woodit) SM-G826	MS 3116F10-6S (environmental)	MS 3106A-14S-6S MS 3106E-14S-6S (environmental)

3.3.2 Digital Interface Box Connections

Figure 3-10 shows the digital interface box connections for J1 to the power supply and receiver device.

Cables should be selected according to the following guidelines, depending upon the overall cable length between the box and counter card.

1. Cable length up to 50 feet: a twisted shielded pair is recommended for the gate signals and interrogation signals (optional). Power signals can be routed using any properly sized multiconductor cable. For areas not subject to electrical noise, a high quality shielded multiconductor cable can be used for all signals, including power.

2. Cable length between 50 and 300 feet: Use a high quality 100 ohm twin axial cable such as Belden 8227 for the positive and negative pulse duration "gate" signals. The power supply wires are routed through an additional multiconductor cable, selected and sized according to industry standards. Wire gage for dc power to the interface box should be selected to ensure minimum possible voltage drop.

3.3.3 Digital Counter Card Connections

Tables 3-3, 3-4, and 3-5 show the counter card output connection tables. In order to select the proper table, the following order variables must be known.

A)	Stroke	________inches (mm)
B)	Resolution	________inches (mm)
C)	Recirculations	________=N
D)	Output format	________BCD____natural binary
E)	Optional inputs/ outputs	________latch inhibit (input)

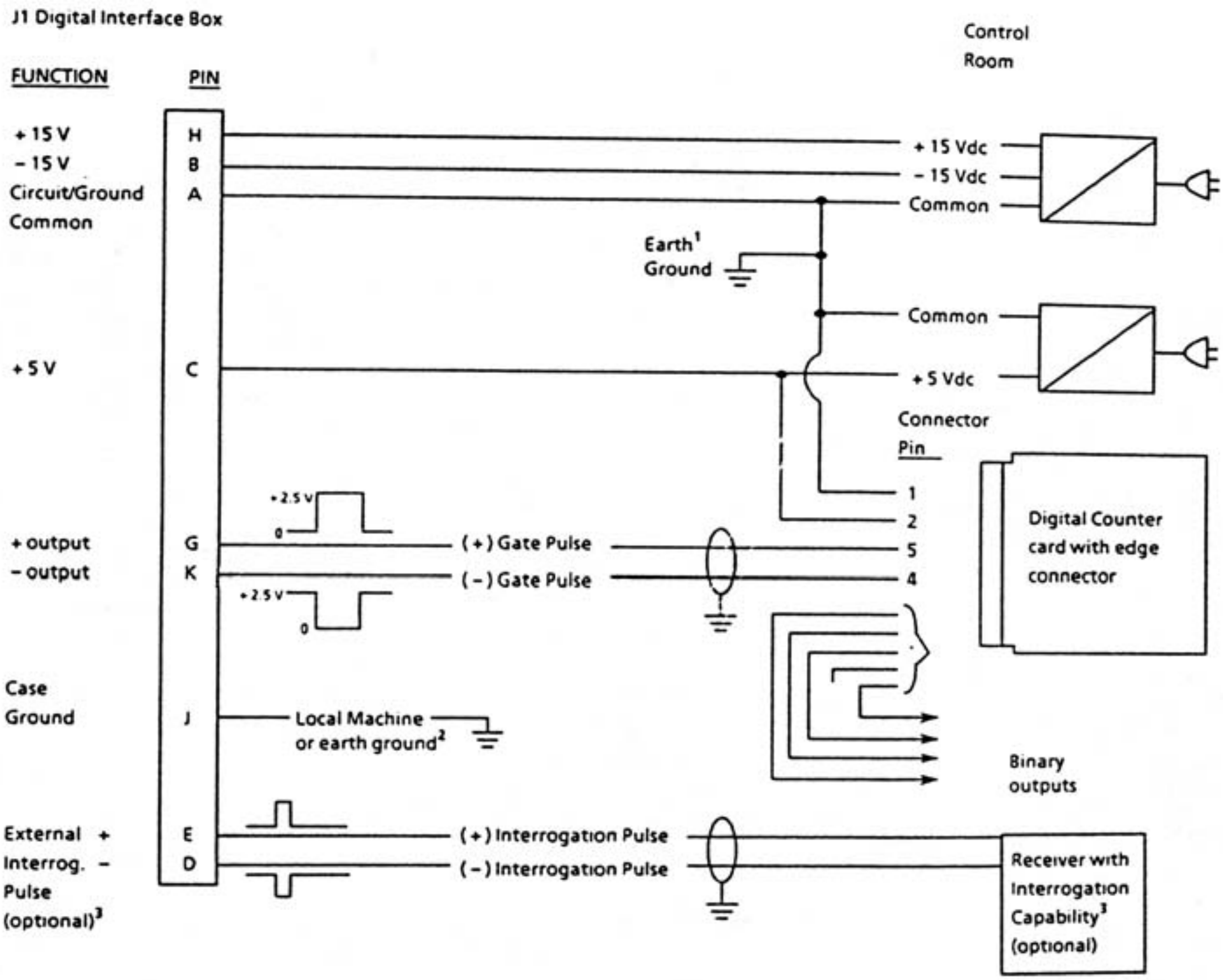
The counter card divider, if supplied, is determined knowing A, B, and C, and is obvious from the table description.

<u>Series 60 Counter Cards</u>
Refer to Figure 3-10 for power input (+5 Vdc) and interface box gate signal connections.

Pin 24 on the counter card is normally connected to the latch pulse (output), and is normally low; high during update of output.

Optionally, a latch inhibit (input) is supplied on pin 24. By applying a ground (sink) to pin 24, the updating of the binary output is frozen and the output does not change.

Series 80 Counter Cards (available 6/88)
Latch inhibit input is now standard on pin 24 for all Series 80 counter cards. No connection or TTL high allows updating to continue.



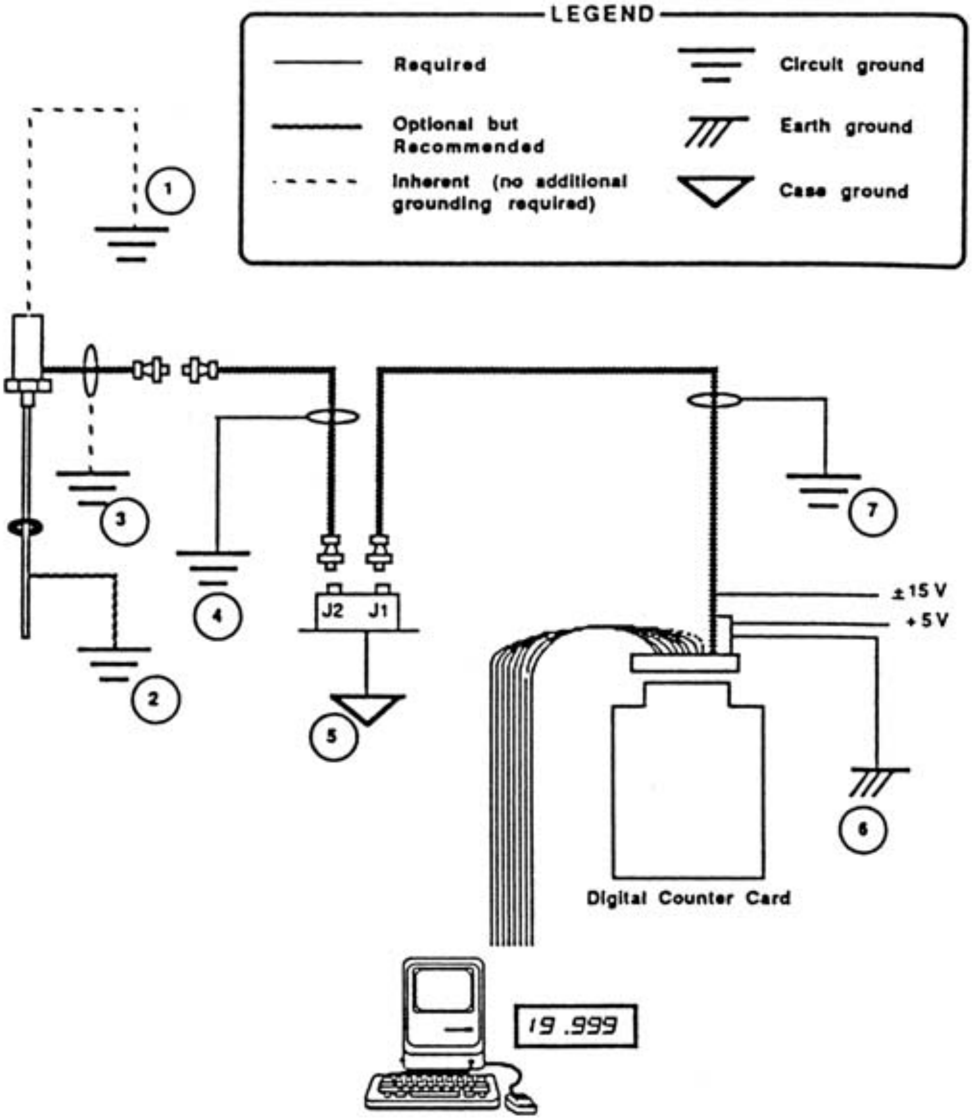
[1] It is common practice to apply earth ground to power supply common terminals near power supply
[2] Case ground is normally applied by installation of box to machine or local equipment
[3] Must be specified with order

LA-A136

Figure 3-10. Signal and Power Wiring, Digital Systems

Table 3-3. J1 Connections

J1 Signal/Function	J1 Pin
dc Common	A
− 15 Vdc Power	B
+ 5 Vdc Power	C
External Interrogation Pulse − (Optional)	D
External Interrogation Pulse + (Optional)	E
+ Gate Output	G
+ 15 Vdc Power	H
Case Ground	J
− Gate Output	K



1. Blue dust cover (NEMA 1) is at circuit ground. Do not apply additional ground. Stainless steel or aluminum ruggedized head cover (NEMA 4, NEMA 6) is at same potential as transducer rod.

2. It is good practice to apply a machine, local, or earth ground to the transducer rod.

3. Transducers with integral cable have circuit ground applied to the cable shield. The ground does not pass through the connector to the extension cable or digital interface box.

4. Connect extension cable shield to circuit ground or local earth ground.

5. Digital interface box case is floating with respect to all grounds. It is good practice apply a local, earth or machine ground to this case.

6. Circuit or "reference" ground is established by connecting the power supply common(s) to earth ground. Do not apply additional grounds to circuit ground (at the transducer head, integral cable shield, or digital box output cable).

7. Digital interface box outputs should be shielded and grounded.

Figure 3-11. Required and Recommended Grounding

Table 3-4 is based upon a counter card with [÷1] divider (factory set). A single card is capable of 18 bits natural binary output maximum.

For the 27-28 MHz crystal, the resulting resolution and recirculations vs stroke are as follows:

1. For 0.000125 inches, N=32 recirculations, stroke up to 32 inches.
2. For 0.00025 inches, N=16 recirculations, stroke up to 65 inches.
3. For 0.0005 inches, N=8 recirculations, stroke up to 131 inches.
4. For 0.001 inches, N=4 recirculations, stroke up to 262 inches.
5. For 0.002 inches, N=2 recirculations, stroke up to 524 inches.
6. For 0.004 inches, N=1 recirculations.

Table 3-4. Counter Card Output (÷1)

Pin	Bit Weight	Decimal Value	Bit	Maximum Counts vs Number of bits*
10	LSB		2^0	1 = 1 bit
9			2^1	3 = 2 bit
8			2^2	7 = 3 bit
7			2^3	15 = 4 bit
14			2^4	31 = 5 bit
13			2^5	63 = 6 bit
12			2^6	127 = 7 bit
11			2^7	255 = 8 bit
18			2^8	511 = 9 bit
17			2^9	1023 = 10 bit
16			2^{10}	2047 = 11 bit
15			2^{11}	4095 = 12 bit
20			2^{12}	8191 = 13 bit
21			2^{13}	16,383 = 14 bit
22			2^{14}	32,767 = 15 bit
19			2^{15}	65,535 = 16 bit
23			2^{16}	131,071 = 17 bit
25	MSB*		2^{17}	262,143 = 18 bit

* MSB determined by dividing stroke by resolution and comparing to maximum counts. For example, 25 inches/0.001 = 25,000. This requires a maximum count of 32,767, yielding an MSB at pin 22.

Table 3-5 is based upon a counter card with [÷2] divider (factory set). A single card is capable of 17 bits natural binary output maximum.

For the 27-28 MHz crystal, the resulting resolution and recirculations vs stroke are as follows:

1. For 0.000125 inches, N=64 recirculations, stroke up to 16 inches.
2. For 0.00025 inches, N=32 recirculations, stroke up to 32 inches.
3. For 0.0005 inches, N=16 recirculations, stroke up to 65 inches.
4. For 0.001 inches, N=8 recirculations, stroke up to 131 inches.
5. For 0.002 inches, N=4 recirculations, stroke up to 262 inches.
6. For 0.004 inches, N=2 recirculations, stroke up to 524 inches.
7. For 0.008 inches, N=1 (or none) recirculations.

Table 3-5. Counter Card Output (÷2)

Pin	Bit Weight	Decimal Value	Bit	Maximum Counts vs Number of bits*
9	LSB		2^{0}	1 = 1 bit
8			2^{1}	3 = 2 bit
7			2^{2}	7 = 3 bit
14			2^{3}	15 = 4 bit
13			2^{4}	31 = 5 bit
12			2^{5}	63 = 6 bit
11			2^{6}	127 = 7 bit
18			2^{7}	255 = 8 bit
17			2^{8}	511 = 9 bit
16			2^{9}	1023 = 10 bit
15			2^{10}	2047 = 11 bit
20			2^{11}	4095 = 12 bit
21			2^{12}	8191 = 13 bit
22			2^{13}	16,383 = 14 bit
19			2^{14}	32,767 = 15 bit
23			2^{15}	65,535 = 16 bit
25	MSB*		2^{16}	131,071 = 17 bit

* MSB determined by dividing stroke by resolution and comparing to maximum counts. For example, 25 inches/0.001 = 25,000. This requires a maximum count of 32,767, yielding an MSB at pin 19.

Table 3-6 is based upon a counter card with [÷4] divider (factory set). A single card is capable of 16 bits natural binary output maximum.

For the 27-28 MHz crystal, the resulting resolution and recirculations vs stroke are as follows:

1. For 0.000125 inches, N=125 recirculations, stroke up to 8 inches.
2. For 0.00025 inches, N=64 recirculations, stroke up to 16 inches.
3. For 0.0005 inches, N=32 recirculations, stroke up to 32 inches.
4. For 0.001 inches, N=16 recirculations, stroke up to 65 inches.
5. For 0.002 inches, N=8 recirculations, stroke up to 131 inches.
6. For 0.004 inches, N=4 recirculations, stroke up to 262 inches.
7. For 0.008 inches, N=2 recirculations, stroke up to 524 inches.
8. For 0.016 inches, N=1 (or none) recirculations.

Table 3-6. Counter Card Output (÷4)

Pin	Bit Weight	Decimal Value	Bit	Maximum Counts vs Number of bits*
8	LSB		2^0	1 = 1 bit
7			2^1	3 = 2 bit
14			2^2	7 = 3 bit
13			2^3	15 = 4 bit
12			2^4	31 = 5 bit
11			2^5	63 = 6 bit
18			2^6	127 = 7 bit
17			2^7	255 = 8 bit
16			2^8	511 = 9 bit
15			2^9	1023 = 10 bit
20			2^{10}	2047 = 11 bit
21			2^{11}	4095 = 12 bit
22			2^{12}	8191 = 13 bit
19			2^{13}	16,383 = 14 bit
23			2^{14}	32,767 = 15 bit
25	MSB*		2^{15}	65,535 = 16 bit

* MSB determined by dividing stroke by resolution and comparing to maximum counts. For example, 25 inches/0.001 = 25,000. This requires a maximum count of 32,767, yielding an MSB at pin 15.

When ordered as BCD, the counter card provides a BCD output. BCD code is a binary method of representing decimal numbers. The BCD code for a decimal number is a string of four-bit binary numbers, each of which represents one decimal digit. Only the following binary groups are used:

Decimal	Binary	Decimal	Binary
0	0000	5	0101
1	0001	6	0110
2	0010	7	0111
3	0011	8	1000
4	0100	9	1001

For example, the decimal number 8.74 is encoded in BCD as a 12-bit binary number:

8	.	7	4	=	8.74
1000	.	0111	0100	=	1000.01110100

In many cases, the BCD code for a stroke length yields a range of BCD numbers where some bits never change value. For example, 19.999 inches is represented in BCD by the 20-bit number

00011001.100110011001

Notice that, for all values from 0 up to 19.999, the first three bits will likewise be zero. This means that the remaining 17 bits are sufficient to encode a stroke of 19.999 inches; that is, one 18-bit counter card is sufficient.

Table 3-7 lists the maximum stroke length versus number of significant bits for a resolution of 0.001 inch.

Table 3-7. BCD Representations of Stroke

X (maximum stroke length in inches)	BCD Value of X	Required Number of Bits
7.999 (or 8)	0111.1001 1001 1001	15
9.999 (10)	1001.1001 1001 1001	16
19.999 (20)	0001 1001.1001 1001 1001	17
39.999 (40)	0011 1001.1001 1001 1001	18*
79.999 (80)	0111 1001.1001 1001 1001	19*
99.999 (100)	1001 1001.1001 1001 1001	20*
199.999 (200)	0001 1001 1001.1001 1001 1001	21*

*An additional counter card is used for this range.

Table 3-8 can be used to determine connections for BCD output digital counter cards.

To determine the applicable connections, you must know the stroke length and resolution. Subtract the resolution from the stroke length to obtain a maximum reading (column 1). Refer to column 7 to determine the decimal equivalent of each digit, knowing the desired decimal position. An example is worked out in Figure 3-12.

Table 3-8. BCD Output Connections

(1) Max reading	(2) No. of active bits	(3) Active Digits	(4) Pin connections Card A	Card B	(5) Binary Weight	(6) Digit	(7) Check Appropriate Column Resolution			
										other
			8		1	1 Least Significant	.0001	.001	.01	
			7		2					
			14		4					
		1	13		8					
			12		1	2	.001	.01	.1	
			11		2					
			18		4					
		2	17		8					
			16		1	3	.01	.1	1.	
			15		2					
			20		4					
999	12	3	21		8					
1999	13	3-1/4	22		1	4	.1	1.	10.	
3999	14	3-1/2	19		2					
7999	15	3-3/4	23		4					
9999	16	4	25		8					
19999	17	4-1/4	9*	8	1	5	1.	10	100.	
39999	18	4-1/2		7	2					
79999	19	4-3/4		14	4					
99999	20	5		13	8					
199999	21	5-1/4		12	1	6 Most Significant	10.	100.	10000.	
399999	22	5-1/2		11	2					
799999	23	5-3/4		18	4					
999999	24	6		17	8					

* Used only with 4-1/4 digits. For 4-1/2 or more digits, 5th digit is on card B.

Example:	Order Specification:	Stroke = 200 inches Resolution = .001 inches

Result: Maximum reading will be 199.999 inches (200 inches) this yields 5-1/4 digits, where the "1" is considered 1/4 of a digit. Go to column 1 and find 199999 = maxreading. The connections will be per (4), where the Least Significant digit is pins 8, 7, 14, and 13, card A. The Most Significant digit is pin 12 on card B. The next LSD is pins 8, 7, 14, and 13 on card B. Pin 9 is not used, due to footnote. Resolution for pin 12 is 100 place; for the 5th digit is 10 place; etc. Refer to middle column (7)

The following connection table is provided for BCD output digital counter card(s). To determine the applicable connections, the resolution and stroke length must be known, yielding a maximum reading; column 1. Refer to column 7 to determine the decimal equivalent of the particular digit in question, knowing the desired decimal point position.

(1) Max reading	(2) No. of active bits	(3) Active Digits	(4) Pin connections Card A	Card B	(5) Binary Weight	(6) Digit	(7) Check Appropriate Column Resolution			
										other
			8		1					
			7		2	1 Least Significant	.0001	001	.01	
			14		4					
		1	13		8					
			12		1					
			11		2	2	.001	.01	.1	
			18		4					
		2	17		8					
			16		1					
			15		2	3	.01	.1	1.	
			20		4					
999	12	3	21		8					
1999	13	3-1/4	22		1					
3999	14	3-1/2	19		2	4	.1	1.	10.	
7999	15	3-3/4	23		4					
9999	16	4	25		8					
19999	17	4-1/4	~~9*~~	8	1					
39999	18	4-1/2		7	2	5	1.	10	100.	
79999	19	4-3/4		14	4					
99999	20	5		13	8					
199999	21	5-1/4		12	1					
399999	22	5-1/2		~~[illegible]~~	2	6 Most Significant	10.	100.	10000.	
799999	23	5-3/4		~~[illegible]~~	4					
999999	24	6		~~[illegible]~~	8					

* Used only with 4-1/4 digits. For 4-1/2 or more digits, 5th digit is on card B.

Figure 3-12. Sample BCD Output Connection Table

3.3.4 Wiring Procedure

The general wiring and checkout procedure is as follows:

1. Route the power and signal cables to the interface box. Do not run near high voltage lines or contacting equipment. Mark the power supply wires at the interface box J1 connector end of cable and connect the panel end of cable to the proper power supply terminals.

2. Connect the (+) and (-) gate signal wires to the counter card edge connector. Do not connect the edge connector to the card at this time.

3. Solder all cable wires to the appropriate J1 pins on the MS3116F12-10S box mating connector. Use heat shrink tubing over each solder connector to protect the connections from shorts. Make sure that cable shields do not make contact with the connector pins or the connector shell. Apply tape or a rubber boot over any exposed cable shield before tightening the cable clamps. Check for wiring shorts between pins after connector assembly.

CAUTION

Be sure all connections are correct before applying power. Voltages applied to the gate signal connector pins G or K (or optional D, E) will damage interface box.

4. Turn on power to the power supplies and take voltage readings on the J1 female connector between the appropriate pins. Check all other pins to ensure that no voltage is present.

5. Solder to the binary output on the digital counter card edge connector using ribbon cable or suitable wire harness.

6. Solder the 5 Vdc power supply to pins 1(-) and 2(+) on the counter card edge connector. Apply heat shrink tubing to the connector terminals to protect from shorts to other terminals.

7. Connect the power supply common for the ±15 V and +5 Vdc supplies together and ground them to earth ground. Refer to Figure 3-10.

8. Connect the counter card edge connector to the card. Connect the MS connector to the interface box J1 connector.

9. Plug in the transducer cable into the J2 interface box connector.

10. Apply power, and observe readings at the receiver device while moving the magnet along the transducer rod. If readings are satisfactory, go to Subsection 3.4 system calibration.

3.4 System Calibration

There are no adjustments on the interface box or the transducer. Instead, the system is calibrated at the counter card or by external means. The scaling (inches per count) is determined by a fixed frequency crystal oscillator, while the zero point is determined by resettable DIP switches on the counter card. Generally, the system components do not show shift, age, or drift over time, and recalibration is not necessary. However, calibration may be used to compensate for mechanical wear on external mechanical parts connected to the magnet or the transducer.

3.4.1 Re-zeroing the Series 80 Digital Counter Card

On Series 80 counter cards, the zero point is preset at the factory, using a pair of DIP switches, S1 and S2. Zero is set at 2 inches from the hex flange of the transducer, or at a distance specified by the customer. If reverse output is specified, the zero point is set at 5 inches or 7 inches from the tip of the transducer rod. The DIP switches are normally covered with RTV or otherwise protected, to prevent accidental resetting.

There are three ways of changing the zero setting:

a. **Mechanical Offset.**
The zero position can be adjusted by changing the mechanical offset of the magnet relative to the transducer rod. This requires a coupler device which permits a screw adjustment of the magnet.

The installer fabricates a coupler device to hold the magnet. The coupler should include adjustment screws that allow fine adjustments of the magnet along the transducer rod. Move the magnet to obtain a zero reading.

If the coupler does not allow magnet position adjustment, it can sometimes be used to lock the magnet in place, while shims or washers are used to move the transducer relative to the magnet (Do not attempt this if the unit is installed in a hydraulic cylinder).

b. **Software Programming.**
In some applications it is possible (and preferable) to maintain a zero offset in software at the receiver. This permits quick re-zeroing without adjusting the magnet or resetting the DIP switches.

For the detailed procedure, consult the manual for the receiver device. Move the magnet to the desired zero position and set the receiver reading to zero.

In most cases, the zero offset is determined by adding the binary complement to the reading observed with the magnet in the desired zero position.

c. **Resetting the Counter Card with DIP Switches**
For this procedure, the receiver device must be capable of reading each of the Counter Card output bits. For example, the System CRT or LED display may be connected to each bit connection on the input module. If this is not possible, a string of LEDs must be connected to the Counter Card connector to read each active bit (Refer to Figure 4-1 for a typical connection). Figures 3-13 and 3-14 show DIP switches S1 and S2, along with tables for determining the switch settings.

Binary Output

Take the following steps (Refer to Figure 3-13):

1. Before changing any DIP switch positions, record the factory-set positions for reference.

2. Move the magnet to the desired null position. Clamp it in place to prevent movement.

3. Reset all switch segments to the LO (closed) position, taking note of alignment marks on the board.

4. If a P.L.C. or readout device indicates the equivalent counts, write this value in row A of the diagram in Figure 3-11. Then convert this number to binary and write it in row B. To ensure that the count is correct, move the magnet through its stroke and observe the count change. For example, a 24-inch stroke unit with 0.001 resolution should yield a 24,000 count change.

   Alternatively, read each active bit on the counter card output and record into row B of the diagram.

5. Determine the complement of the binary number in row B, by changing 1s to 0s and 0s to 1s. Write this complement into row C.

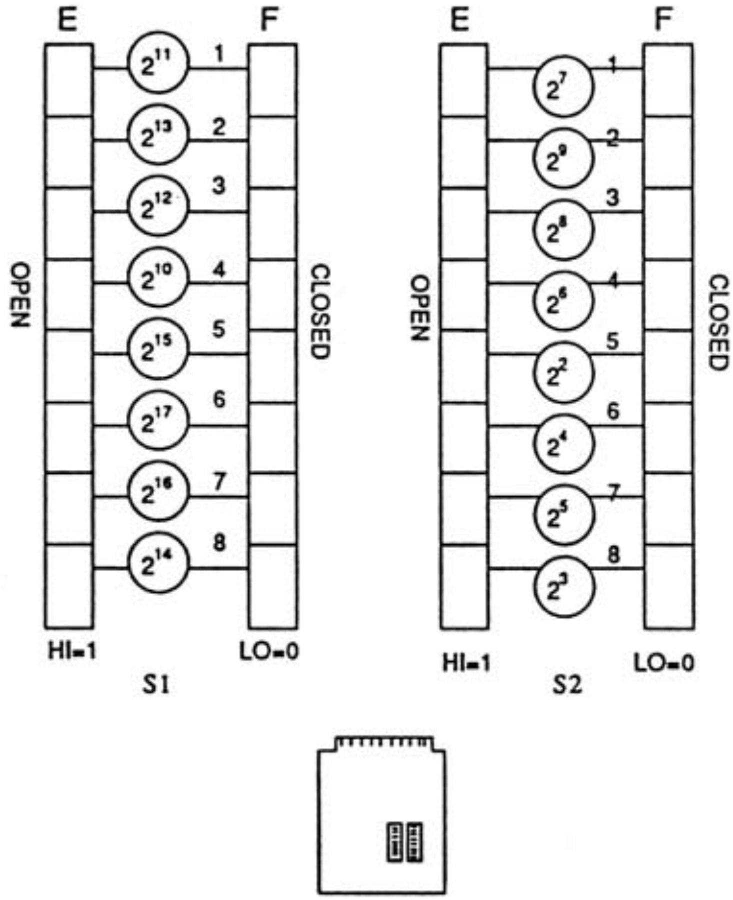
6. Use the number from row C to mark the columns E and F. If the corresponding bit from C is 1, mark and X in column E (open or HI). If the corresponding bit is 0, mark an X in column F (closed or LO).

7. Turn off power, then set each switch segment to the value (HI or LO) indicated by the Xs in columns E and F.

8. Apply power to the system and check that the output is now zero.

Pin Number*																			
Bit	2^{17}	2^{16}	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
A. Reading in Counts																			(if available)
B. Reading in binary																			(from LEDs or binary of A)
C. Complement																			(complement of B)
*Use Tables 3-4 to 3-8 to determine pin numbers																			

If value in row C is 1, mark X in column E.
If value in row C is 0, mark X in column F.



Dip switch settings should be viewed with the edge card connector facing upward.

Figure 3-13. Setting DIP Switches (Binary System)

BCD Output

Take the following steps (Refer to Figure 3-14):

1. Before changing any DIP switch positions, record the factory-set positions for reference.

2. Move the magnet to the desired null position. Clamp it in place to prevent movement.

3. Reset all switch segments to the LO (closed) position, taking note of alignment marks on the board.

4. If a CRT or other readout device indicates a decimal value (in inches, mm, or other units), convert this value from decimal to BCD binary, and record it in row B of the diagram in Figure 3-14. (Decimal-to-BCD conversion is explained on page 3-20.)

   Alternatively, read each active bit on the counter card output and record this BCD number in row A of the Diagram. Then convert row A to decimal, and record it in row B.

5. Subtract each digit in row B from 9, and record the result in row C.

6. Convert row C into BCD binary and record the result in row D.

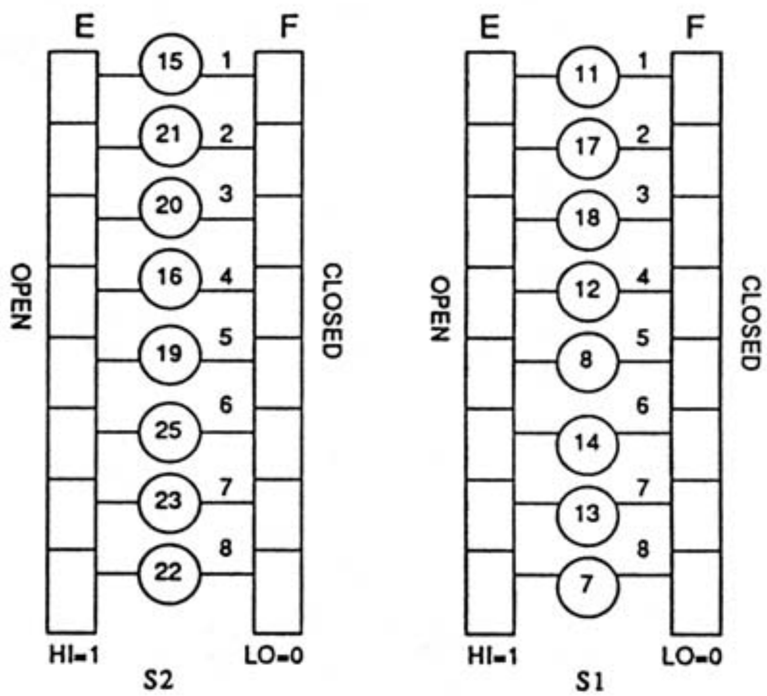
7. Use the number from row C to mark the columns E and F. If the corresponding bit from C is 1, mark an X in column E (open or HI). If the corresponding bit is 0, mark an X in column F (closed or LO).

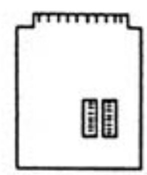
8. Turn off power, then set each switch segment to the value (HI or LO) indicated by the Xs in columns E and F.

9. Apply power to the system and check that the output is now zero.

Digit	10^3				10^2				10^1				10^0				Not Used		
Bit	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0			
Pin Number	25	23	19	22	21	20	15	16	17	18	11	12	13	14	7	8	9	10	
A. Reading in BCD																			(from LEDs, if used)
B. Reading in Decimal																			(from BCD indicator, if used)
C. 9 - Decimal																			Subtract B from 9
D. Converted to BCD																			Convert C to BCD

If value in row D is 1, mark X in column E.
If value in row D is 0, mark X in column F.





Dip switch settings should be viewed with the edge card connector facing upward.

If a second counter card is provided (for 5 or 6 digit BCD), use this table in addition to the table above

Digit	10^4			
Bit	2^3	2^2	2^1	2^0
Pin Number	13	14	7	8
A. Reading in BCD				
B. Reading in Decimal				
C. 9 - Decimal				
D. Converted to BCD				

Figure 3-14. Setting DIP Switches (BCD System)

3.4.2 Re-zeroing the Series 60 Digital Counter Card (former design)

The Series 60 Counter Card does not contain any internal adjustment for zero setting in the field. Re-zeroing this card can only be done by mechanical offset or software programming. These procedures are described earlier in Subsection 3.4.1.

3.4.3 Scaling Series 60 and Series 80 Digital Counter Cards

1. Scaling is not normally required for Digital Counter Cards, because most digital systems are supplied as scaled systems. (Refer to the earlier Subsection 1.3.1 for a discussion of scaling.)

2. Scaling is required for systems supplied as "unscaled" systems, or if the counter card is not matched to the transducer serial number. Scaled systems will have a discrete scale factor, such as 0.001 inches per count, and do not require scale factor determination.

   To determine the scale factor (or to check system performance), move the magnet to a known measured position on the transducer near full stroke. Observe the output and record it.

   The scale factor is determined by dividing the measurement by the observed number of counts or the observed output in BCD. As an example,

   Measurement = 36.000 inches
   Reading = 35,420 counts (or 35.420 in BCD)

   $$\text{Scale Factor} = \frac{36}{35{,}420} = 0.0010163 \text{ inches per count (inches per inch in BCD)}$$

3. For systems that will be used for only one or more discrete positions, move the magnet to the known measured positions that will be repeated during system operation. Observe and record each reading.

   Compare each observed reading to the measured reading and record results. Use the observed readings in software programming as the set point or control points.

   For greater system accuracy, repeat this step and average the readings.

   NOTE

   To obtain maximum system accuracy, perform the above procedures at or near the actual system operating conditions.

4. For systems that are used for continuous readings or variable set points, apply the scale factor in Step 2 to software programming so that each reading is multiplied by the scale factor (consult receiver device manual). Continue to Step 5.

5. Move the magnet to a known, measured position at or near half of stroke. Observe the reading and compare to the measurement. If the reading varies by more than ±0.05% full stroke, repeat Step 2 using a different measurement near full stroke. Check the new scale factor by performing Step 5 again.

NOTE

> To obtain maximum system accuracy, several scale factors should be calculated using different measurements and the factors should be averaged. Readings should be taken at or near actual system operation conditions.

6. If the readings do not relate to the stroke position, or appear erratic, refer to Section 4 for troubleshooting information.

Section IV
Troubleshooting

This section consists of troubleshooting procedures to be used when operational problems are encountered.

NOTE

The following procedures are for general troubleshooting purposes. Purchase of replacement components should not be determined solely upon results of these tests. Consult MTS Temposonics for recommendations before purchasing replacement system components.

4.1 General

If the output signal is erratic or unchanging (random), the first procedure is to turn off power and recheck Subsections 3.3.1, 3.3.2, and 3.3.3 for possible errors in mechanical or electrical installation. Once all procedures have been checked, continue for diagnostic test procedures to determine the cause of fault.

The possible causes of faulty output are listed below in order of frequency (probability) of occurrence, and should be checked in order.

		References
1.	Improper power supply/power connection	Figure 3-10 and Subsection 4.2
2.	Mismatched system components*	Subsection 1.3
3.	Ground loops/improper grounding*	Figure 3-11
4.	Improper wiring procedure for J-1 on DIB power and signal connections	Figure 3-10
5.	Improper wiring procedure for J2 on DIB to transducer	Subsection 3.3.1
6.	Improper wiring procedure for counter card connections*	Subsection 3.3.3
7.	Incorrect receiver device or software*	Subsection 4.4
8.	Improper magnet mounting*	Subsection 3.2
9.	EMI noise, affecting transducer, transducer cable, or DIB/counter card cable*	Figures 3-10 and 3-11
10.	Circuit fault within interface box	
11.	Circuit fault within counter card	
12.	Circuit fault within transducer	

** Will cause erratic or unstable output*

The equipment required for diagnostic testing is:

1. Analog or digital voltmeter
2. Circuit tester or ohmmeter
3. Oscilloscope, 50 mHz (15 mHz minimum) (dual channel preferred)

4.2 Power Supply Check

This procedure will determine if the power supply rating is sufficient, or if there is a voltage drop occurring in the field wiring.

Perform the following procedure to check power supply voltage and connections at the interface box.

1. Remove power and disconnect J-1 10 pin connector from interface box. Also remove edge connector from counter card. Turn power on and check open circuit voltages at the connector pins of the box mating connector.

2. Pin H should read +15 with respect to A.
   Pin B should read -15 with respect to A.
   Pin C should read +5 with respect to A.

3. Check power supply voltages under load as follows: Connect a 150 ohm resistor (or similar 1.5 watt, 12-15 Vdc load between pins H and A and read the voltage across t resistor. The value should be 14.25 Vdc minimum.

4. Connect a 220 ohm resistor (or similar 1 watt, 12-15 Vdc load*) between pins B and A and read the voltage across the resistor. The value should be -14.25 Vdc minimum.

5. Connect a 10 to 12 ohm resistor (or similar 2 watt, 5-6 Vdc load*) between pins B and A and read the voltage across the resistor. The voltage should read +4.75 Vdc minimum.

Perform the following procedure to check the power supply voltage and connections at the 5 volt power supply.

1. Connect a 4 ohm, 5 watt resistor (or similar 1.2 amp load*) across the +5 Vdc terminals of the power supply. The voltage should be +4.75 Vdc minimum.

2. Reconnect the counter card and digital interface box. Read the voltage at the counter card edge connector, pin 2 with respect to pin 1. The voltage should read +4.75 Vdc minimum.

---

* *Automotive 12 or 6 Vdc bulbs of the proper wattage are acceptable alternatives.*

4.3 Wiring

Improper wiring between the transducer and J-2 box connector or the counter card and J-1 box connector can cause either an erratic output or complete loss of output signal.

The following instructions should be followed to check all connections.

1. Disconnect or remove dc power to the system.

2. Trace all wiring from the counter card to the interface box. Refer to Figure 3-8, and instructions Subsection 3.3.2 for proper connection diagrams and cable types.

3. Trace all wiring from the transducer to the interface box J-2 connector. Ensure that maximum cable length and type is observed. Refer to Table 3-1A and installation Subsection 3.3.1 for color codes, cable numbers etc.

4. Check system grounds. Figure 3-11 shows a typical circuit diagram with the required and optional grounds. Ensure that circuit ground is made at one location only to avoid ground loops. If erratic or unstable output is encountered, recheck all earth grounds and cable grounds.

5. Connect an oscilloscope to the + and - gate signals at the counter card edge connector, pins 5 and 4 with respect to circuit ground pin 1. Check for presence of each gate separately, since loss of either gate will cause loss of output. If the pulse width modulates with change in magnet position, continue to Subsection 4.4 for counter card testing.

4.4 Counter Card Digital Output Test Procedure

The counter card output, (14-18 bits typical), is a true high TTL level signal nominal 0 to 5 volts dc.

The receiver device must be selected to interface with the TTL level signal of the counter card. Most devices offer a TTL input option or a specific model selection designed for TTL only.

If the user suspects an improperly selected or malfunctioning receiver device, the counter card output may be tested using LED's.

Perform the following procedure:

1. Disconnect the receiver device from the binary output of the counter card. This is usually performed at the receiver device input terminals.

2. Connect 4 or more LED's between the binary output ; power supply ground as shown in Figure 4-1. Select ł (or digit) which will give a reading which is eas interpreted. (Four of the "middle" bits for natural bina tenths or units place for BCD). The LED's should be rat for 3-5 Vdc, 50 mA maximum. The LEDs light when the is high. (Note that output voltage will drop under load - s TTL data books.)

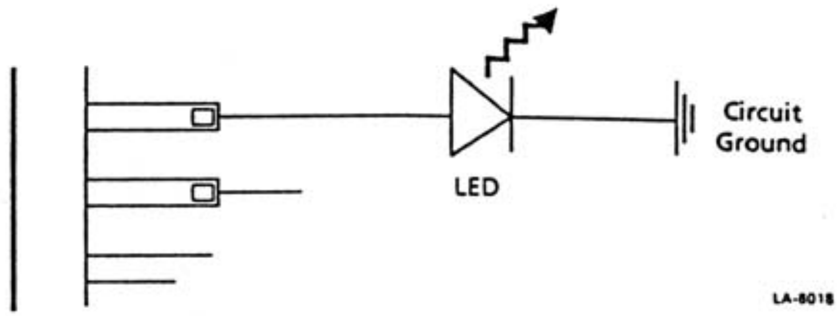


Figure 4-1. Testing Counter Card Output

3. With the above test set-up procedure, some of the LED' should light immediately. If no LED's light, move th magnet through the stroke of the transducer and ensure tha one or more LED's light. If none respond, recheck the in; of the LED's and the power supply connections to the card (pins 1 and 2).

4. To check the counter card reading move the magnet betwee two measured positions on the stroke, and record the LEI readings, as "hi" or "lo". Take the complement of the readings, and calculate the decimal equivalent of the readings. For example, in natural binary, a decima equivalent is:

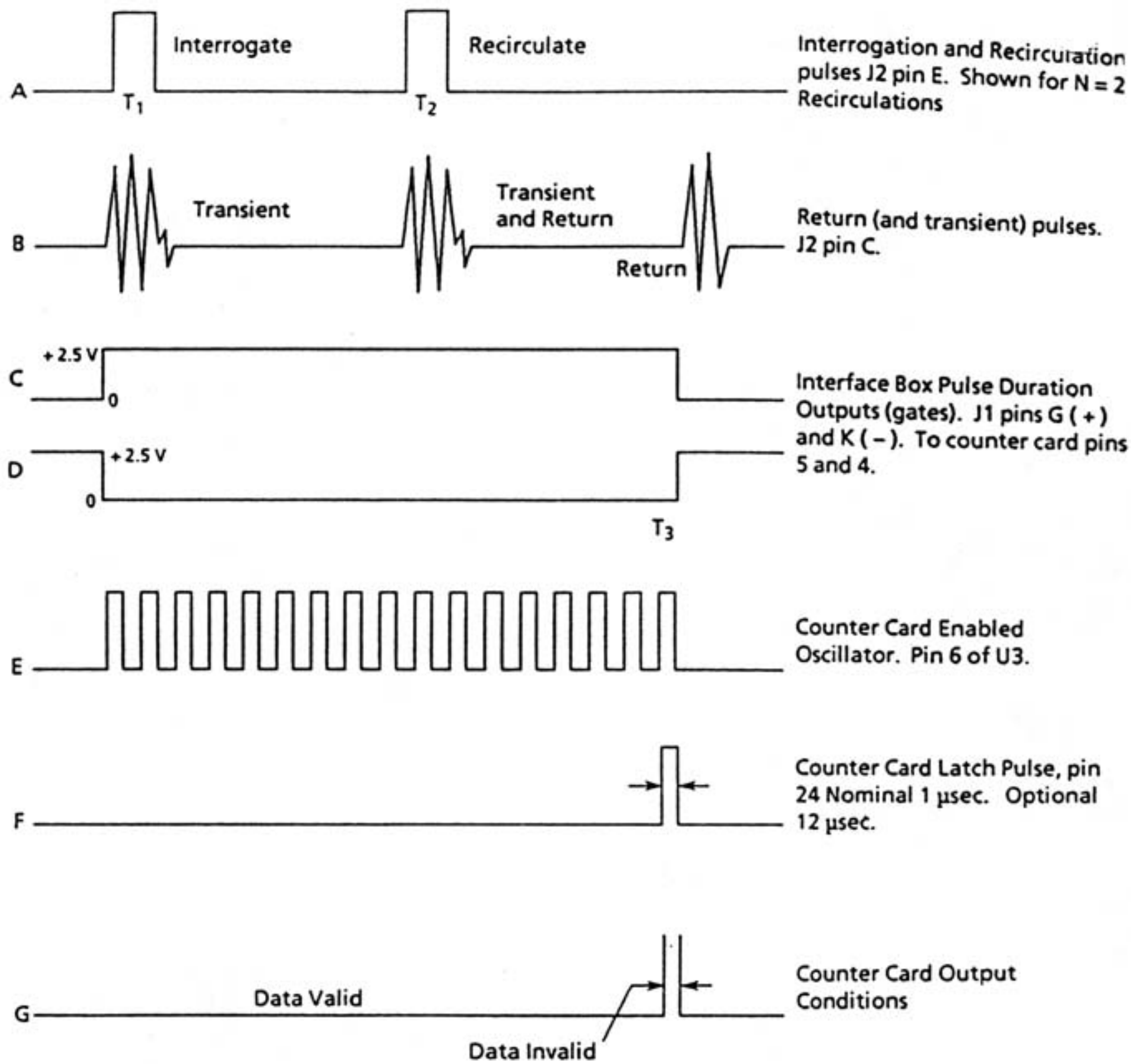
Table 4-1. LED Test

Bit Number	LED	Complement (A)	Decimal Weight (B)	A x B
2^{0}*			0.001	
2^{9}	Hi = 1	Lo = 0	0.512	0
2^{10}	Lo = 0	Hi = 1	1.024	1.024
2^{11}	Hi = 1	Lo = 0	2.048	0
2^{12}	Lo = 0	Hi = 1	4.096	4.906
			Sum =	5.930 Inches of stroke
* Shown for reference purposes				

Repeat this table for position 2, and compare the inches of stroke measured to the inches of stroke observed.

NOTE

A change in reading between 2 points on the stroke is a general indication of proper system operation.



T_3 = 9.05 µsec/inch × N × (position + 4.5 inches) (approximate)

LA-A137

Figure 4-2. System Level Signal Timing

MTS®

Sensors Division

Temposonics™ Brand Linear Displacement Transducer System with Direct Digital Output

Supplement

The following procedures were developed after the printing of the Temposonics™ Brand Linear Displacement Transducer System with Direct Digital Output manual. This publication is designed to be used as a supplement to Section IV Troubleshooting.

NOTE

The MTS Customer Service Department should be consulted before attempting any repairs in the field. Failure to consult MTS will void the warranty.

4.5 Power Supply Check

1. Disconnect DIB from 10-pin connector.

2. Turn power supply on and check the following voltages on J1 (10-pin) mating connector with respect to pin-A (gnd):

   pin H = +15Vdc
   B = -15Vdc
   C = +5Vdc

3. If voltages are correct, turn power off and connect 10-pin back to DIB.

4.6 Digital Interface Box (DIB)

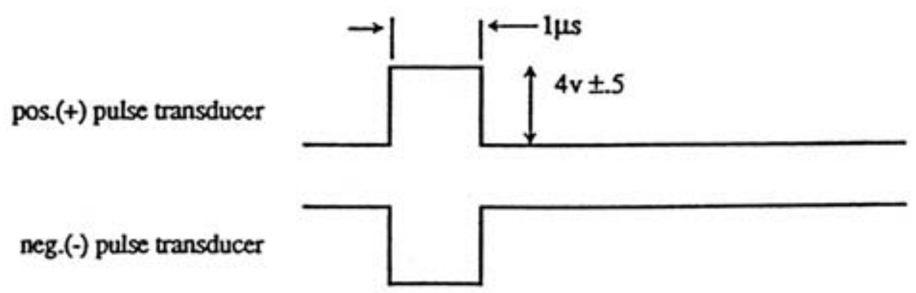
1. With power off, disconnect transducer from DIB.

2. Turn power on. Check the following voltages on pin-B (gnd) on J2 (6-pin) of the DIB.

   Pin A = +12 to +15Vdc
   D = -13.5 to -15Vdc
   F = +11.5 to +12Vdc

3. If any voltage is missing or is not within specification, send the DIB to the factory for repair. If voltages are correct go to step 4.

4. With power on, use an oscilloscope to check the interrogation signal to the transducer on J2 pin-E on the DIB. If no signal is present, send the box to the factory for repair. If the signal looks like the example below, go to step 5.



5. Hook oscilloscope to pin-C on the transducer cable. The return pulse and recirculations should be present. Go to step B6 if these signals are present. Send the DIB to the factory for repair if the signals are not present. Below is an example of a DIB with 4 recirculations.

Volts/div: 1v
Time/div: 5µs (delay mode)

6. Look at the gate signals on pins G(+) and K(-) on the J1 connector. A complimentary 0 volts low 5 volt high TTL level output should be present. Send the DIB to the factory for repair if gate signals are not present.

4.7 Modifying a DIB from INTERNAL interrogation to EXTERNAL Interrogation

Consult drawings 650110 and 250068.

1. Remove the 4 cover screws on the DIB.
2. Remove cover with PCB connected. Turn component side up with J1 to the left and J2 to the right as you face the board.
3. Remove the 555 timer from the bottom of the 16-pin DIP socke (position U1B) pins 1-4 and 13-16.
4. Install a 9637 IC* on the top side of the same 16-pin DIP socket (position U1) pins 5-8 and 9-12.
5. Install a 100Ω resistor between pins D and E of J1-10 pin connector (or E1 and E2).

4.8 Modifying a DIB from EXTERNAL interrogation to INTERNAL Interrogation

Consult drawings 650110 and 250068.

1. Remove the 4 cover screws on the DIB.
2. Remove cover with PCB connected. Turn component side up with J1 to the left and J2 to the right as you face the board.

3. Remove the 9637 IC from the top side of the 16-pin DIP socket (position U1B) pins 5-8 and 9-12.

4. Install a 555 timer** on the bottom side of the same 16-pin DIP socket (position U1) pins 1-4 and 13-16.

5. Install the proper value (or next highest available value) resistor in R1 location. Use the following formula to determine the resistor value:

   R1 (KΩ) - [T(msec) x 14.43] - 1

6. Install R2 (499Ω) , C1 (.1µF) and C13 (.01µF) if R1 is not present.

* IC 9637 is manufactured by Texas Instruments P/N UA9637 ACP
** The 555 Timer is manufactured by RCA P/N LM555CN

4.9 Changing Recirculations

1. Remove the 4 cover screws on the DIB.

2. Locate the jumper wire in the center of the PCB attached to "0" and some other number ranging from 1 to 8. There are 8 possible points.

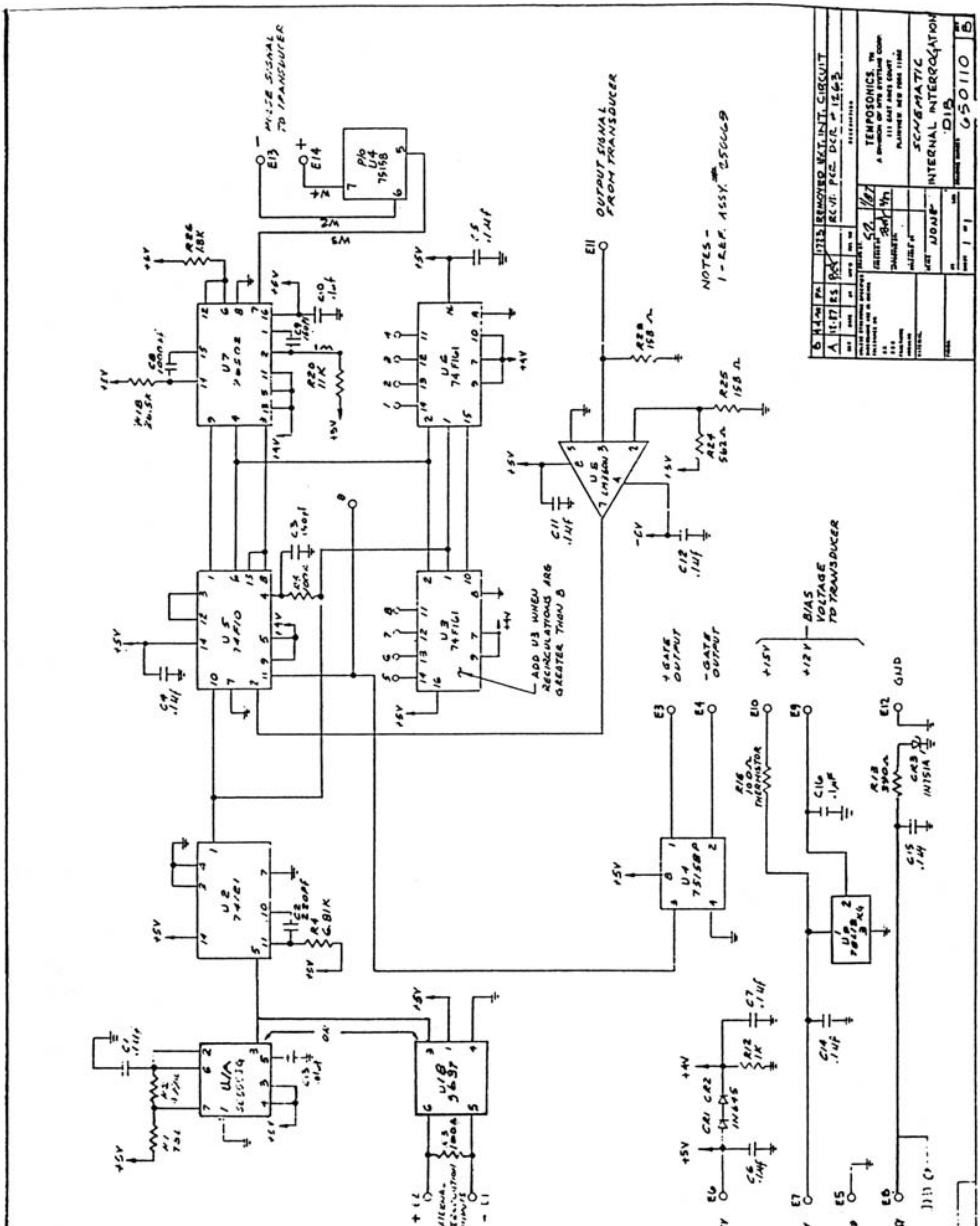
3. Use the chart below to change from 0 to X to get N (number of desired circulations).

4. Install U3 (74161) for recirculations above 8.

Jumper from 0 to X		N
0 to 1	=	1
0 to 2	=	2
0 to 3	=	4
0 to 4	=	8
0 to 5	=	16
0 to 6	=	32
0 to 7	=	64
0 to 8	=	128

NOTE

Any DIB having a high number of circulations can be changed to a lower number without having an effect on the interrogation pulse timing.


OUTPUT SIGNAL FROM TRANSDUCER
BIAS VOLTAGE TO TRANSDUCER
+GATE OUTPUT
-GATE OUTPUT
ADD U3 WHEN RECIRCULATIONS ARE GREATER THAN 8
TEMPOSONICS, INC.
SCHEMATIC INTERNAL INTERROGATION
G50110

4.10 Changing Polarity

This procedure is used when connecting a negative pulse transducer to a positive pulse DIB, or when connecting a positive pulse transducer to a negative pulse DIB.

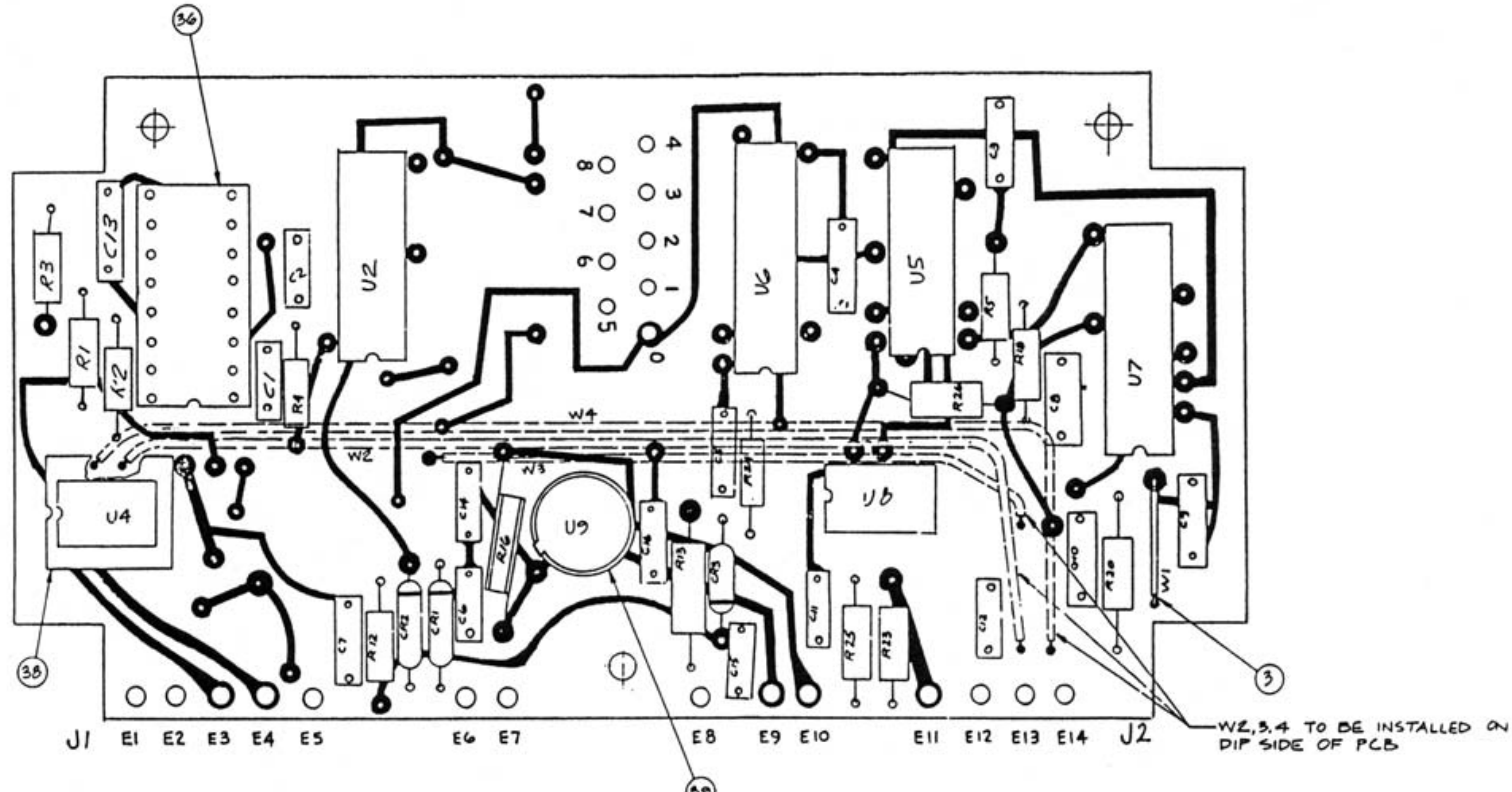
The polarity of the interrogation pulse is determined by the type of driver within the transducer head electronics. The serial number on the transducer ends in a P (positive) or N (negative). The polarity is indicated by the 10th digit in the transducer model number.

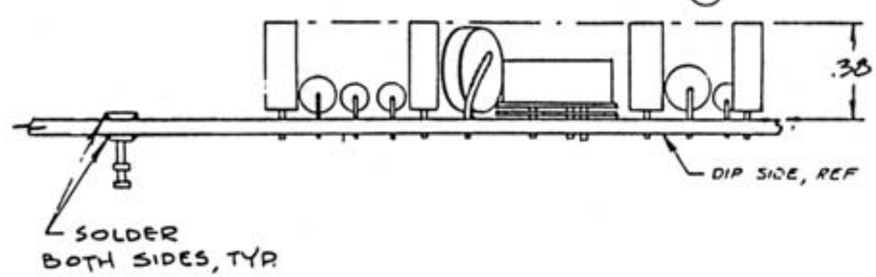
1. Remove the 4 cover screws on the DIB.
2. Remove cover with PCB connected. Turn component side up with J1 to the left and J2 to the right as you face the board.
3. Make one connection to pin-E on the J2, 6-pin connector, which represents the (+) or (-) pulse.

Example: post E14 to J2 pin-E is (+) polarity
post E13 to J2 pin-E is (-) polarity

```
^=post      component side
            ------------------------------   PCB
            ^^^^^  ^^   ^^^   ^^^^
             E1       through         E14

            ------------------------------   Cover
             J1                 J2
```





NOTES:
1 - MASK ALL UNPOPULATED HOLES BEFORE SOLDERING
2 - REF SCHEMATIC #650109

REV	DATE	BY			DESCRIPTION
H	1/13/90	RA			REV PER DCR # 1447
G	4/4/89				REV PER DCR # 1363
F	4-11-88				REV PER DCR # 1332
E	3-10-88	PK			REV PER DCR # 1303
D	2-5-88	PK			REV PER DCR # 1288
A					REV. PER DCR # 12[illegible]

TEMPOSONICS, TM
A DIVISION OF MTS SYSTEMS CORP
111 EAST AMES COURT
PLAINVIEW, NEW YORK 11803

ASSY, INTERFACE PCB (WIDE TEMP)

4/1

1 = 1

250068 H

Sensors Division
MTS Systems Corporation
Box 13128
Research Triangle Park, North Carolina 27709
Telephone 919-677-0100 Fax 919-677-0200

0990-550019 Supplement

MTS® Sensors Division

Temposonics®
Intrinsically Safe Position Sensors

Ordering Guide &
Installation and Instruction Manual

Part Number 550420
Revision D 2/20/98

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GENERAL INFORMATION

MTS PHONE NUMBERS	
To place orders:	Contact your local distributor or call: 1-800-633-7609 or 919-677-0100
Application questions:	1-800-633-7609
Service:	1-800-248-0532
Fax:	919-677-0200
SHIPPING ADDRESS	***HOURS***
MTS SYSTEMS CORPORATION Sensors Division 3001 Sheldon Drive Cary, North Carolina 27513	*Monday - Thursday* 8:00 a.m. to 6:30 p.m. EST or EDT *Friday* 8:00 a.m. to 4:30 p.m. EST or EDT

1. INTRODUCTION

Temposonics position sensors can be used in hazardous environments when connected to approved safety barriers. Factory Mutual approval permits the use of intrinsically safe Temposonics position sensors in Class I, Division 1, Groups A, B, C, and D hazardous locations (see Table 1A below).

Table 1A Hazardous Location Classifications

<table>
<tr><th colspan="4">Class I</th></tr>
<tr><td colspan="4">Flammable Gases or Vapors</td></tr>
<tr><th colspan="4">Division 1</th></tr>
<tr><td colspan="4">May exist because of repair or maintenance operations, or leakage
• Release concentration because of breakdown or faulty operation of equipment or process
• Faulty operation of process which causes simultaneous failure of electrical equipment</td></tr>
<tr><th>Group A</th><th>Group B</th><th>Group C</th><th>Group D</th></tr>
<tr><td>Atmospheres containing Acetylene</td><td>Atmospheres such as:
• Butadiene
• Ethylene Oxide
• Propylene Oxide
• Acrolein
• Hydrogen</td><td>Atmospheres such as:
• Cyclopropane
• Ethyl Ether
• Ethylene</td><td>Atmospheres such as:
• Acetone
• Alcohol
• Ammonia
• Benzene
• Benzol
• Butane
• Gasoline
• Hexane
• Lacquer Solvent Vapors
• Naptha
• Natural Gas
• Propane</td></tr>
</table>

Intrinsic Safety (IS) is based on the principle of restricting the electrical energy transmitted into a hazardous area, thereby ensuring that any sparks or heated surfaces that may occur as a result of electrical failures are insufficient to cause ignition. With intrinsically safe systems, a safe operating environment is provided for personnel and equipment -- voltages are low and no threat of an explosion exists.

COMPONENTS -- INTRINSICALLY SAFE SYSTEMS:

- Temposonics I Linear Displacement Transducer
- (1 ea.) MTL-728 Shunt Diode Safety Barrier (P/N 370140)
- (2 ea.) MTL-710 Shunt Diode Safety Barrier (P/N 370141)
- 24-28 Vdc Power Supply (P/N 380009)
- ± 15 Vdc Power Supply -- required with digital systems and some analog system configurations
- 5 Vdc power Supply -- required with digital systems
- A signal conditioning interface module (see Figure 1.1 -- 'Signal Conditioning')

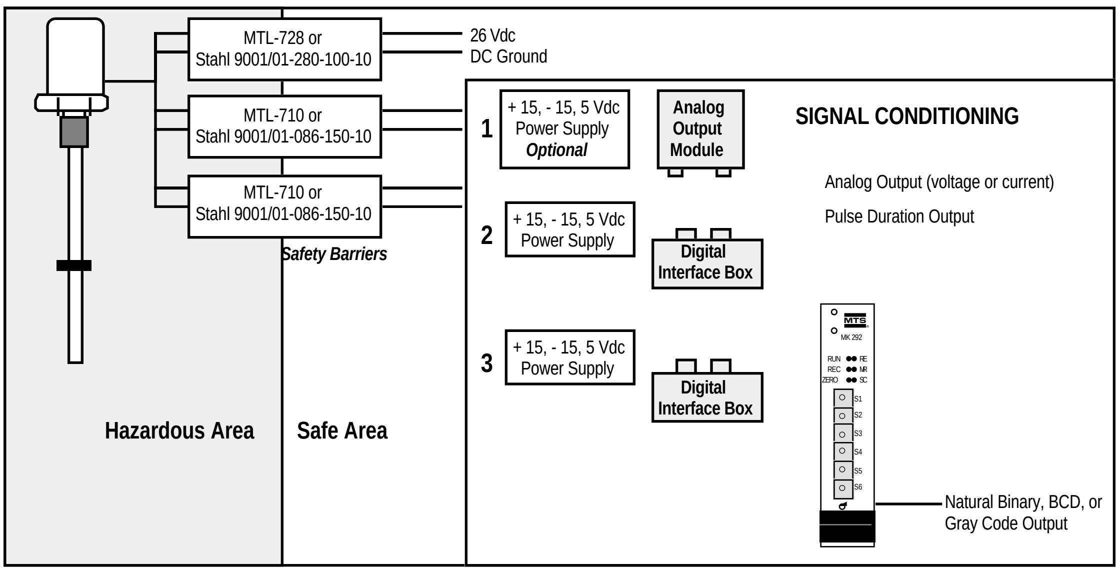


Figure 1.1
Typical System Configuration

2.1 System Specifications

Parameter	Specification
Input Voltage:	• Position Sensor: 26 Vdc • Interface Modules: ± 12 to ± 15 Vdc • Counter Card: 5 Vdc
Displacement:	Up to 25 feet (7620 millimeters)
Dead Space:	For stroke lengths up to 200 inches: 5 inches (127 millimeters) For stroke lengths over 200 inches: 7 inches (177.8 millimeters)
Sensor Styles:	*3 Styles:* 1) Standard, dust-tight 2) Ruggedized, dust-tight (similar to NEMA 1) 3) Ruggedized, splash-proof (similar to NEMA 4)
Non-linearity:	< ± 0.05% of full scale or ± 0.002 inch (±0.05 mm), whichever is greater
Repeatability:	± 0.001% of full scale or ± 0.0001 inch (± 0.002 mm)), whichever is greater
Frequency Response:	Stroke dependent, 200 to 50 Hz for strokes ranging from 12 to 100 inches (305 to 2540 mm). Wider response is available. For digital systems, output is updated at discreet intervals.
Temperature Coefficient: Transducer (length dependent): Electronics:	 3 ppm/°F (5.4 ppm/°C) < 0.00011 in./°F (< 0.00503 mm/°C)
Operating Temperature Head Electronics: Transducer Rod: Analog Output Module: Digital Interface Module MK 292 Digital Output Module	 - 40 to 150 °F (- 40 to 66 °C) - 40 to 185 °F (- 40 to 85 °C) - 40 to 180 °F (- 40 to 82 °C) 35 to 150°F (2 to 65°C) 32 to 140°F (0 to 60°C)
Sensor Operating Pressure:	Factory Mutual certified to 3000 psi continuous, 8000 psi static
Outputs (absolute) Analog: Digital:	 Standard: 0 to 10 Vdc (others voltage outputs are available), Optional: 4 - 20 mA Natural Binary, BCD, Gray Code
Velocity Output (optional)	0 to ± 10 Vdc, polarity of output defines direction of travel *(optional 4-20 mA velocity output is available -- contact MTS for details)*
Magnet Requirement:	Part Number: 201542 (standard) or 201554 if sensor stroke length is over 200 inches
Mounting Distances:	• Temposonics position sensor to safety barriers: 200 feet maximum • Temposonics position sensor to Digital Interface Box: up to 200 feet with Belden 9931 cable • Digital Interface Box to MK 292 Module up to 300 feet with Belden 8227 cable • Temposonics position sensors to Analog Output Module: up to 200 feet with Belden 9931 cable

Specifications are subject to change without notice. Consult MTS for verification of specifications critical to your application.

3.1 Temposonics Intrinsically Safe Position Sensor

I 6 □ □ □ □ □ □ □ □

Enclosure Style
1 = Standard, dust-tight (similar to NEMA 1)
2 = Ruggedized, dust-tight (similar to NEMA 1)
3 = Ruggedized, splash-proof (similar to NEMA 4)

Stroke Length Units
U = U.S. Customary (inches and tenth -- xxx.x inches)
M = Metric (millimeters)

Stroke Length
The value to enter depends on stroke length units indicated above.
For example:
0120 = 12.0 inches or 120 mm
1200 = 120.0 inches or 1200 mm

Null/Dead Space
5 = 5 in. dead space, 2 in. null—standard for strokes up to 200 inches
7 = 7 in. dead space, 2 in. null—standard for strokes over 200 inches
9 = Special (must be specified at time of order)

Cable/Connector (See IMPORTANT NOTE below)
1 = 5 ft. cable with standard, 6-pin connector (for use with Enclosure Style "1")
2 = 5 ft. cable with pigtail connection (for use with Enclosure Style "1")
3 = No cable -- extension cable required, connector attached directly to head assembly (for use with Enclosure Styles "2" or "3")
4 = 25 ft. cable with standard, 6-pin connector (for use with Enclosure Style "1")

IMPORTANT NOTE

Consult Applications Engineering for any installation with cable lengths that exceed 200 feet of total distance between the position sensor and the external conditioning module (analog or digital).

3.2 Extension Cables

I S □ □ □ □ □

Cable Type
S = Standard (Belden 9931)
H = Heavy Duty (Belden 9730)

Length (ft.)
Examples: 25 ft. = 025; 100 ft. = 100
Maximum Length: 200 ft.

Mating Connector
1 = Standard, PN 370018
(For use with sensor Enclosure Style "1")
2 = Ruggedized, P/N 370011
(For use with sensor Enclosure Style "2", refer to Section 3.1 above and Figure 3.1 on next page)
3 = Ruggedized, P/N 370062
(For use with sensor Enclosure Style "3", refer to Section 3.1 above and Figure 3.1 on next page. Also, this connector is available with standard cable only—not compatible with Heavy Duty cable)

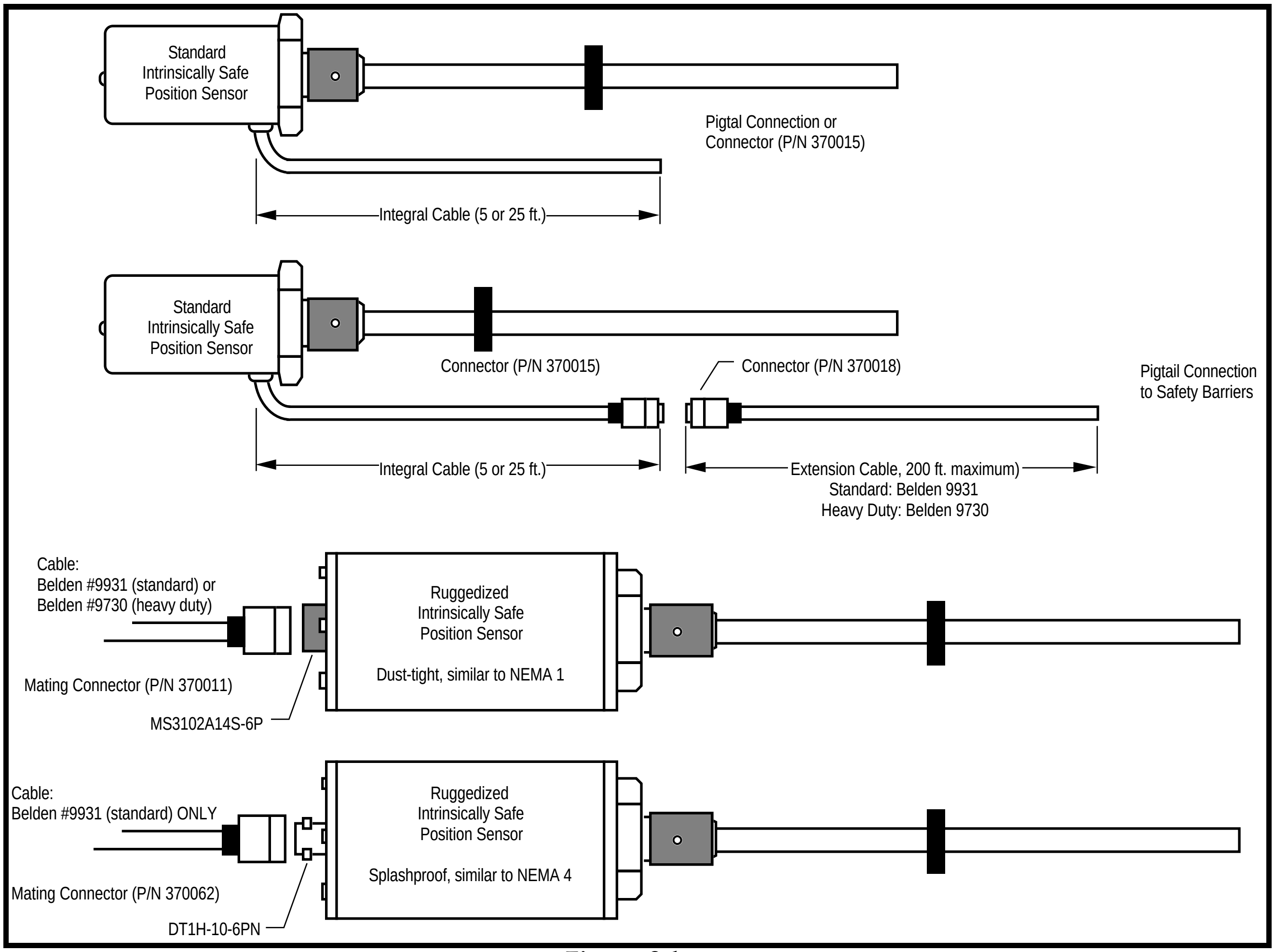


Figure 3.1
Temposonics Intrinsically Safe
Position Sensor Configurations

NOTES:
1. Safety Barriers are hard-wired using a pigtail connection.
2. Maximum cable length between the Temposonics position sensor and the safety barrier is 200 feet.

Table 3A Position Sensor Cable Connections

	CABLE		
Connector Pin #	**Belden 9931** (standard)	**Belden 9730** (heavy duty)	**Functional Description**
A	Red	Red	26 V
B	Black	Black *(twisted with Red wire)*	Common
C	Brown	Green	Return Pulse
D	Blue	Black *(twisted with Green wire)*	Common
E	White	White	Interrogation Pulse
F	Green	Black *(twisted with White wire)*	Common

3.3 Analog Output Module for Intrinsically Safe Systems

Position Sensor Code

□□ □□ □ □ □□□ **I** **6** □ □ □□□□

Enclosure Style
31 = Standard, Strain-relief Connectors
32 = 5 & 6 Pin MS Style Connectors
35 = Plug-in Card, rack mountable
Note: Style '35' requires a 15-pin edge connector (P/N 370034) or card holder (P/N 370170

Displacement Output
Voltage Outputs:
10 = 0 to 10 Vdc
20 = 0 to 10 Vdc, reverse acting
50 = -10 to +10 Vdc
60 = -10 to +10 Vdc, reverse acting
01 = 0 to -10 Vdc
02 = 0 to -10 Vdc, reverse acting

Current Outputs:
03 = 4 to 20 mA ungrounded
04 = 4 to 20 mA ungrounded, reverse acting
05 = 4 to 20 mA grounded
06 = 4 to 20 mA grounded, reverse acting

Special Outputs:
09 = Dual Channel
90 = Differential Output

DC Power Supply Requirement
0 = ± 15 Vdc (for retrofits)
1 = 26 Vdc

Velocity Option
0 = None
1 = Forward acting voltage output
2 = Reverse acting voltage output
3 = Forward acting current output (grounded)
4 = Reverse acting current output (grounded)
5 = Forward acting current output (ungrounded)
6 = Reverse acting current output (ungrounded)

Maximum Velocity
__ __ __ = Maximum Velocity, range = 1 to 400 inches/second or 0.01 to 9.99 meters/second
Note: The 3 digit code represents either inches/second or meters/second depending upon the Stroke Length Units selected.

Intrinsically Safe Sensor

Style
1 = Standard, dust-tight (similar to NEMA 1)
2 = Ruggedized, dust-tight (similar to NEMA 1)
3 = Ruggedized, splashproof (similar to NEMA 4)

Unit of Measurement
U = US Customary (inches and tenths)
M = Metric (millimeters)

Stroke Length
__ __ __ __ = Stroke Length
Note: This 4 digit code represents either inches and tenths or millimeters depending in the Unit of Measurement selected)

3.3.1 Accessories for AOM

- 5 pin female MS connector (P/N 370017)
- 6 pin female MS connector (P/N 370015)

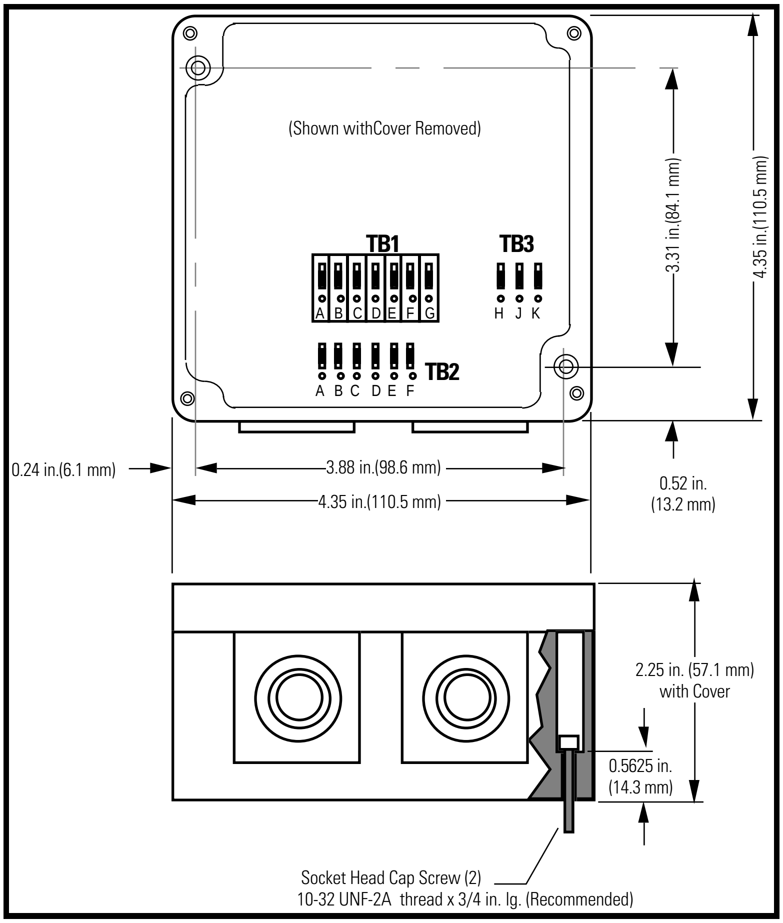


Figure 3.2
Analog Output Module Dimensions

3.4 Digital Interface Box for Intrinsically Safe Systems

I 6 D □ □ □ □ □ □ □ □

Digital Interface Box for Intrinsically Safe System

Interrogation
I = Internal Interrogation
E = External Interrogation

Recirculation Count
0 = 1 Circulation
1 = 2 Recirculations
2 = 4 Recirculations
3 = 8 Recirculations
4 = 16 Recirculations
5 = 32 Recirculations
6 = 64 Recirculations
7 = 128 Recirculations
9 = Other

Style
0 = Standard, ±15 Vdc P.S.; Temp. Range: 35 to 150°F (1.67 to 66°C)
2 = ±12 Vdc P.S.; Temp. Range: 35 to 150°F (1.67 to 66°C)
9 = Special

Unit of Measurement (Sensor Length)
U = US Customary (inches and tenths)
M = Metric (millimeters)

Stroke Length of Sensor
__ __ __ __ = Stroke Length

Note: This 4 digit code represents either inches and tenths or millimeters depending in the Unit of Measurement selected)

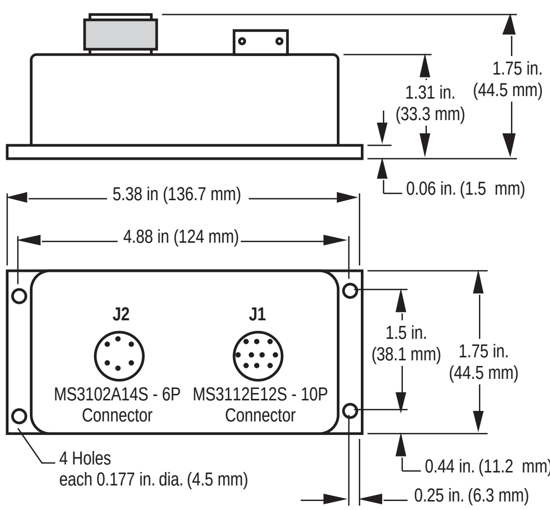


Figure 3.3
Digital Interface Box Dimensions

3.4.1 Accessories for Digital Interface Box

- 10-pin female MS connector (P/N 370013)
- 6-pin female MS connector (P/N 370015)

3.5 MK 292 Digital Output Module for Intrinsically Safe System

MK 292 ☐ ☐ 0 1

MK 292 Digital Output Module

Hardware
- **10** = Card
- **11** = Card with Analog Sub-board Assembly
  (Sub-board assembly: AK294, 0 to 10 Vdc or 10 to 0 Vdc output)
- **50** = Module
- **51** = Module with Analog Sub-board Assembly
  (Sub-board assembly: AK294, 0 to 10 Vdc or 10 to 0 Vdc output)

Software
- **01** = For use with Intrinsically Safe Sensor and Digital Interface Box

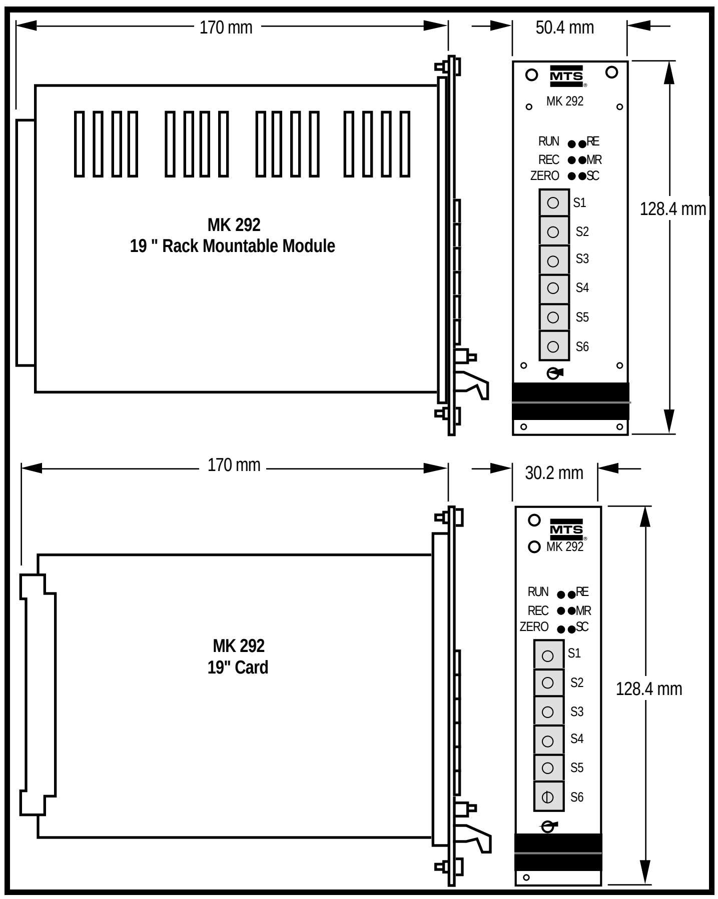


Figure 3.4
MK 292 Module Dimensions

4.1 Installing a Temposonics Position Sensor

Before beginning installation, be sure you know the following dimensions (as illustrated in Figures 4-1 to 4-3.):

- Null Space
- Stroke
- Dead Zone

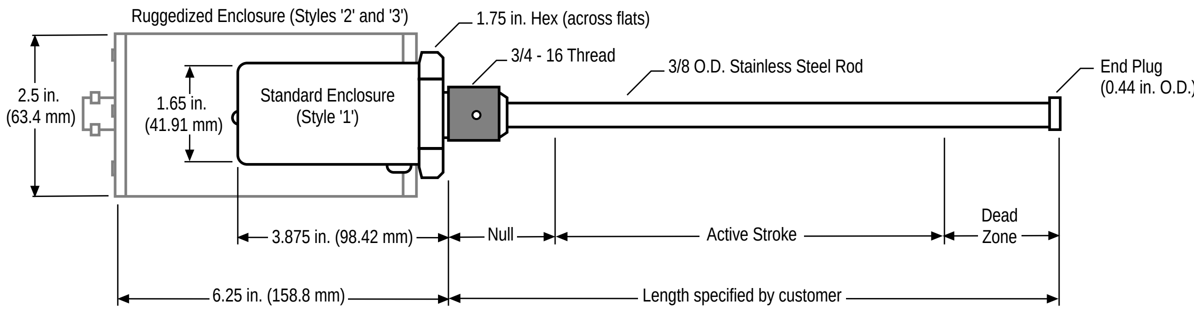


Figure 4.1
Temposonics Intrinsically Safe Position Sensor Dimension

1. Use the 3/4 inch (19 mm), 16 UNF thread of the position sensor to mount it at the selected location. Leave room to access the hex head. If a pressure or moisture seal is required, install an O-ring (type MS 28778-8 is recommended) in the special groove. Use the hex head to tighten the position sensor assembly.

2. Install the permanent magnet over the sensor rod. Mount the permanent magnet to the movable device whose displacement will be measured. To minimize the effect of magnetic materials (i.e. iron, steel, etc.) on the magnetic field of the permanent magnet, ensure the minimum spacing requirements are met as shown in Figures 4.2a-c. (Any non-magnetic materials can be in direct contact with the permanent magnet without affecting performance.)

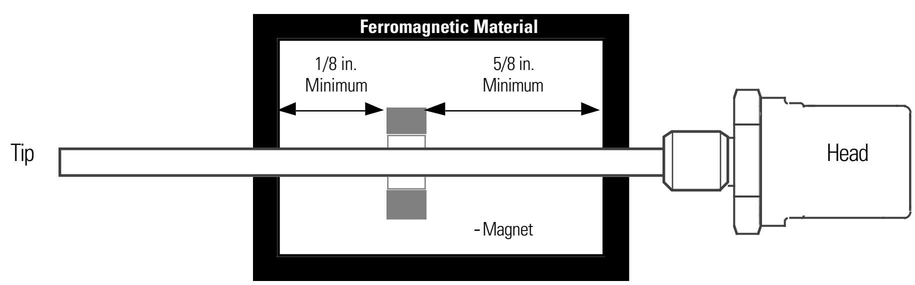


Figure 4.2a
Minimum Magnet Clearance Using Magnetic Supports

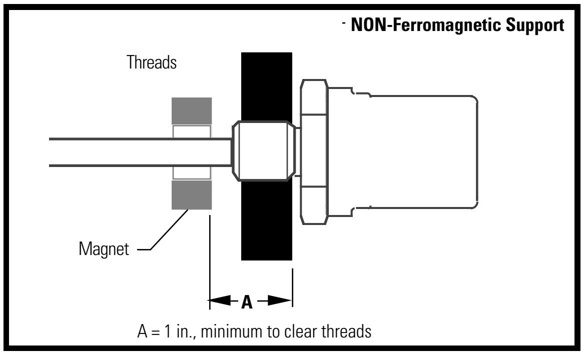


Figure 4.2b
Minimum Null Space Using Non-Magnetic Support

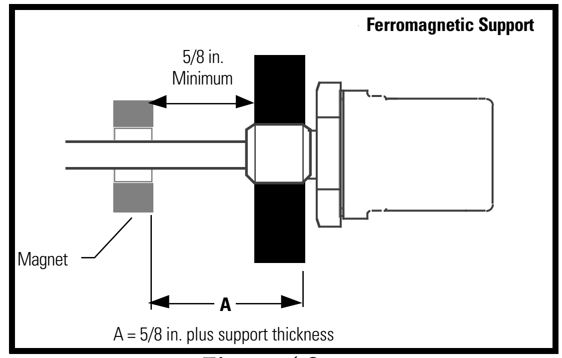


Figure 4.2c
Minimum Null Space Using Magnetic Support

Notes:

1. The magnet must not contact ferromagnetic materials (such as iron or steel). Clearances are required between the surface of the magnet and ferromagnetic material, as shown. Non-ferrous material (such as copper, brass, or 300 series stainless steel) may contact the magnet without affecting sensor performance.
2. Standard Null Space is 2 inches. There is no maximum limit for Null Space. Less then 2 inches can be specified if magnet clearances meet requirements illustrated above.

NOTE

Clearance between the magnet and the sensor rod is not critical. However, contact between the components will cause wear over time. The installation of supports and/or readjustment of the supports is recommended if the magnet contacts the sensor rod.

3. Move the permanent magnet full-scale to check that it moves freely. If not (if the magnet rubs on the sensor rod) you can correct this by mounting a support bracket to the end of the position sensor. Long sensors may need additional supports to be attached to the sensor rod. Transducer supports are described later in this section.

4.2 Types of Sensor Supports

Long sensors (48 inches or longer) may require supports to maintain proper alignment between the sensor rod and the permanent magnet. When sensor rod supports are used, special, open-ended permanent magnets are required.

Transducer supports attached to the active stroke length must be made of a non-ferrous material, thin enough to permit the permanent magnet to pass without obstruction. Because the permanent magnet does not enter the dead zone, supports connected within the dead zone may be made of any material. The main types of supports are loop, channel, and guide pipe supports.

4.2.1 Loop Supports

Loop supports are fabricated from non-ferrous materials, thin enough to permit free movement of the magnet. Loop supports are recommended for straight position sensors. They may be used alone or with channel supports. Figure 4.3 illustrates the fabrication of a loop support.

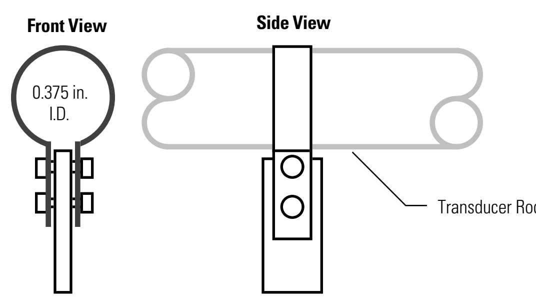


Figure 4.3
Loop Support

NOTE

When open magnets are used, ensure the sensor rod remains within the inside diameter of the magnet throughout the length of the stroke. If the sensor rod is allowed to enter the cut out area of an open magnet, the output signal could attenuate or be lost. See Figure 4.6.

4.2.2 Channel Supports

Channel supports, being typically straight, are normally used with rigid sensors. A channel support consists of a straight channel with loop supports mounted at intervals. The loop supports are required to keep the sensor rod within the channel. Figure 4.4 shows a channel support. Channel supports are available from various manufacturers or may be fabricated.

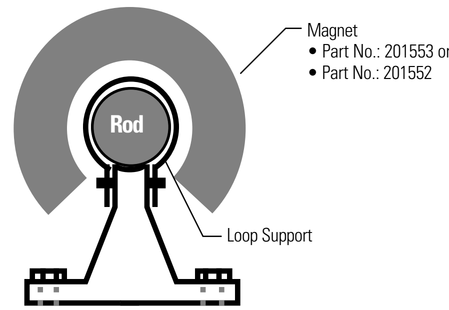


Figure 4.4
Channel Support

4.2.3 Guide Pipe Supports

A guide pipe support is constructed of non-ferrous material, straight or bent to the desired shape. As shown in Figure 4.5, both inside and outside dimensions of the pipe are critical:

- Because the sensor rod is installed inside the pipe, the inside diameter of the pipe must be large enough to clear the rod.
- The outside diameter of the pipe must be small enough to clear the magnet.

Refer to pipe manufacturers' specifications and dimensions (schedule 10, 40, etc.) to select the appropriate size pipe. Guide pipe is typically supported at each end of the pipe.

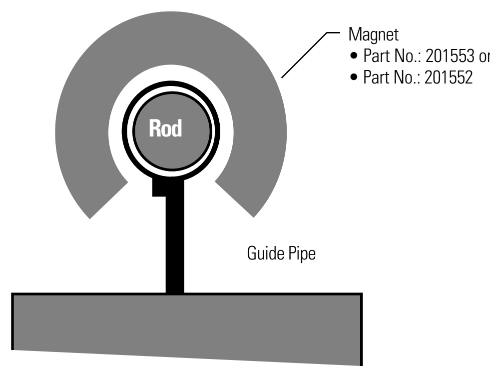


Figure. 4.5
Guide Pipe Support

4.3 Open Magnets

When using an open magnet, make sure the rod is positioned at all times within the "active" zone of the magnet. The position sensor cannot operate properly unless the entire stroke of the sensor rod is located within this zone. The active zone, as shown in Figure 4.6, lies within the inside diameter of the magnet.

Figure 4.6
Active Zone for Open Magnets

4.4 Spring Loading or Tensioning

The sensor rod can be spring loaded or tensioned using a stationary weight. Attach a spring mechanism or weight to the dead zone of the sensor rod with a clamping device -- make sure that the clamp does not deform the rod. The maximum weight or spring tension is 5 to 7 lbs.

4.5 Cylinder Installation

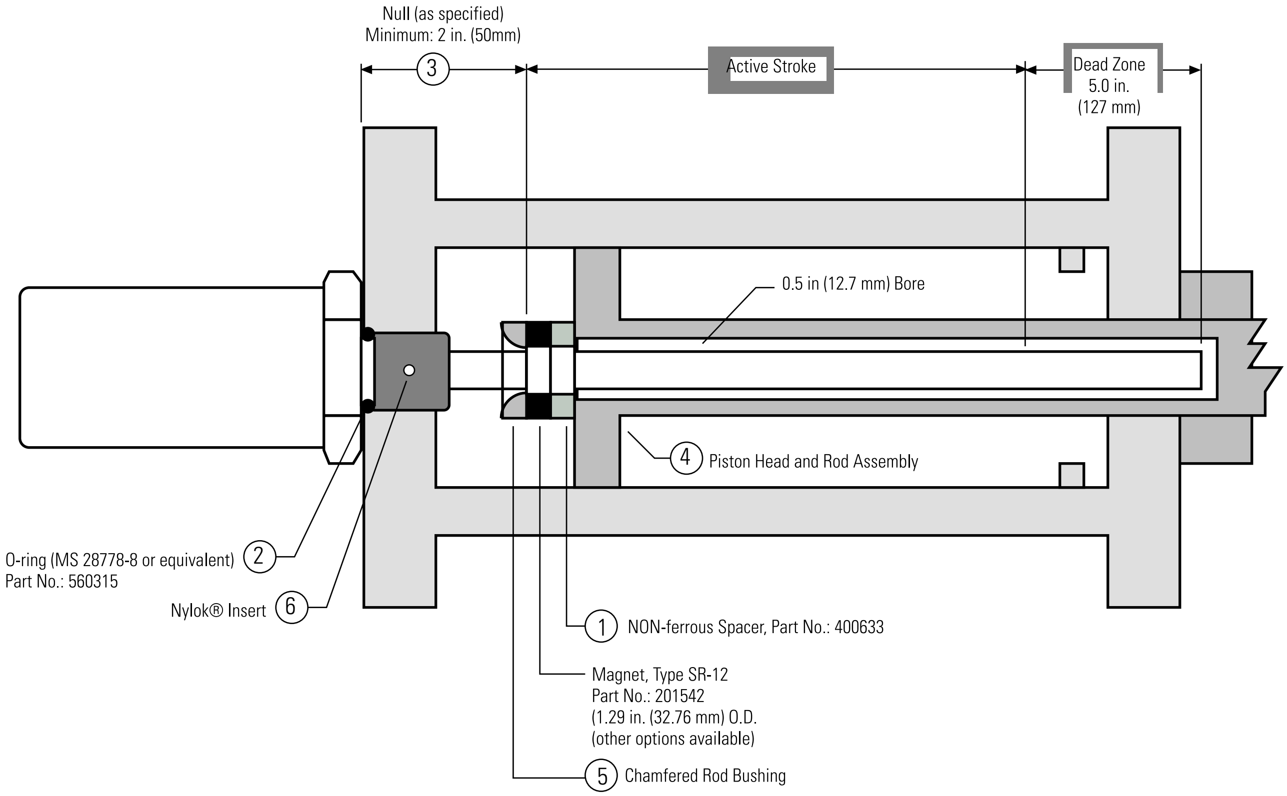
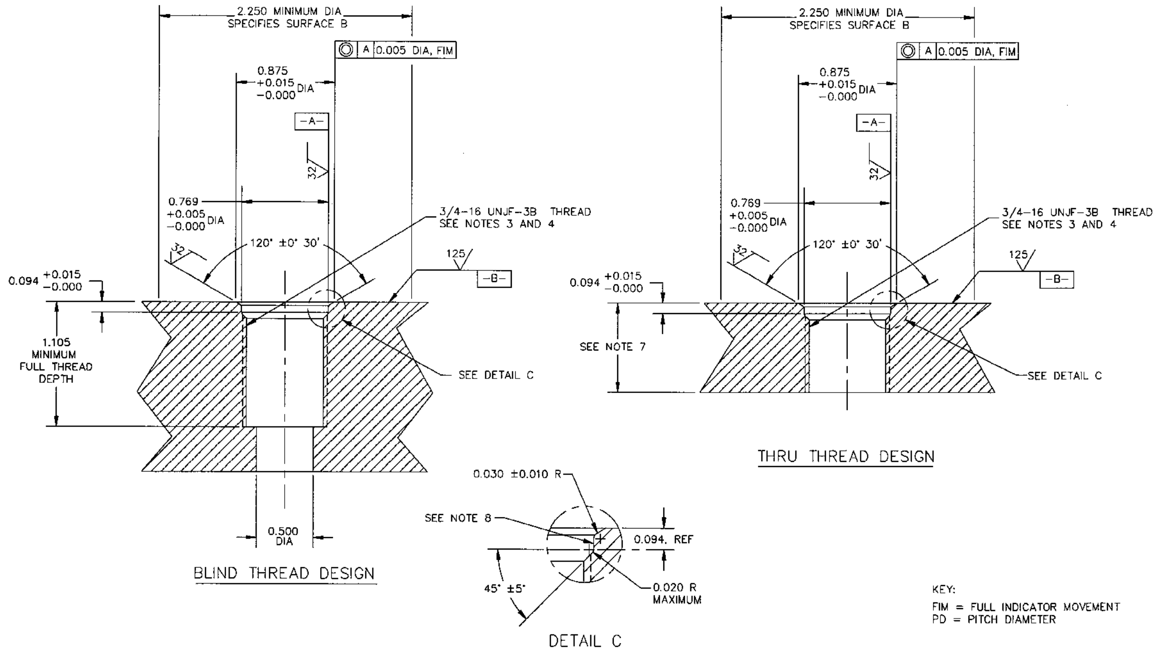


Figure 4.7
Typical Cylinder Installation

Figure 4.7 shows a typical cylinder installation. Review the following before attempting this type of installation.

- Use a non-ferrous (plastic, brass, Teflon®, etc.) spacer [1] to provide 1/8 inch (32 mm) minimum space between the magnet and the piston.
- An O-ring groove [2] is provided at the base of the hex for pressure sealing. MTS uses mil-standard MS33514 for the O-ring groove. Refer to mil-standard MS33649 or SAE J514 for machining of mating surfaces.
- The null space [3] is specified according to the installation design and cylinder dimensions. The analog output module provides a null adjustment. Make sure that the magnet can be mounted at the proper null position.
- The piston head [4] shown in Figure 4.7 is typical. For some installations, depending on the clearances, it may be desired to countersink the magnet.
- A chamfered rod bushing [5] should be considered for stokes over 5 feet (1.5 meters) to prevent wear on the magnet as the piston retracts. The bushing should be made from Teflon or similar material.
- A Nylok self locking insert [6] is provided on the threads. An O-ring groove is provided at the base of the hex head for pressure sealing.
- The recommended bore for the cylinder rod is 1/2 inch (13 mm). The 0.375 in. sensor rod includes a 0.44 in. (12 mm) end plug. Use standard industry practices for machining and mounting of all components. Consult the cylinder manufacturer for applicable SAE or military specifications.



NOTES:
1. Dimensions and tolerances based on ANSI Y14.5-1982.
2. MTS has extracted all pertinent information from MS33649 to generate this document.
3. PD must be square with surface B within 0.005 FIM across 2.250 dia minimum.
4. PD must be concentric with 2.250 dia within 0.030 FIM and with 0.769 dia within 0.005 FIM.
5. Surface texture ANSI B46.1-1978.
6. Use o-ring MTS part number 560315 for correct sealing.
7. The thread design shall have sufficient threads to meet strength requirements of material used.
8. Finish counter-bore shall be free from longitudinal and spiral tool marks. Annular tool marks up to 32 micro-inches maximum will be permissible.

Figure 4.8
O-ring Boss Detail

4.6 Installing Magnets

If the null adjustment is inadequate, you can design a coupler with adjustments to mount the magnet to the measured member.

5.1 Factory Mutual Control Drawing (Drwg. # 650512)

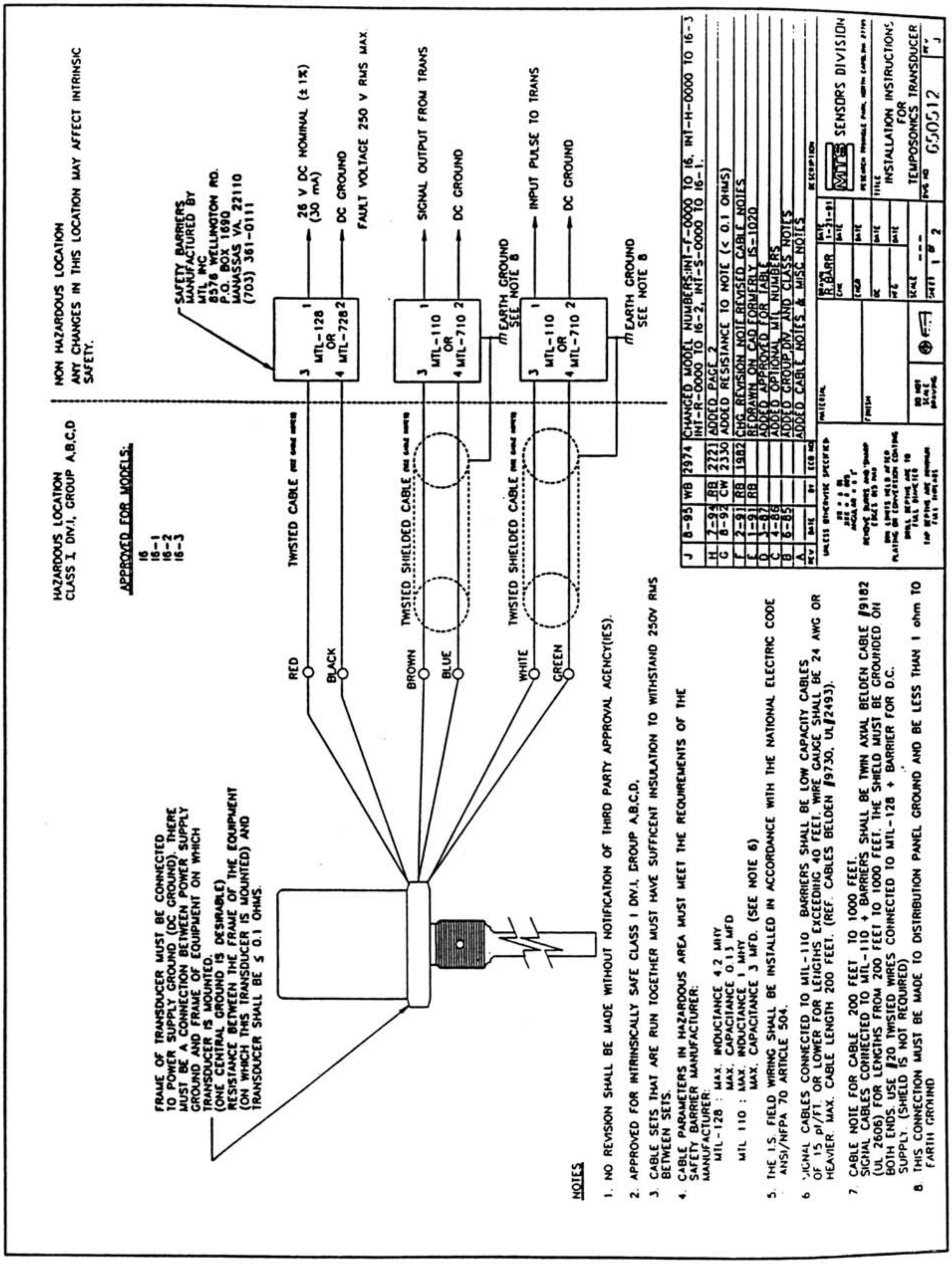


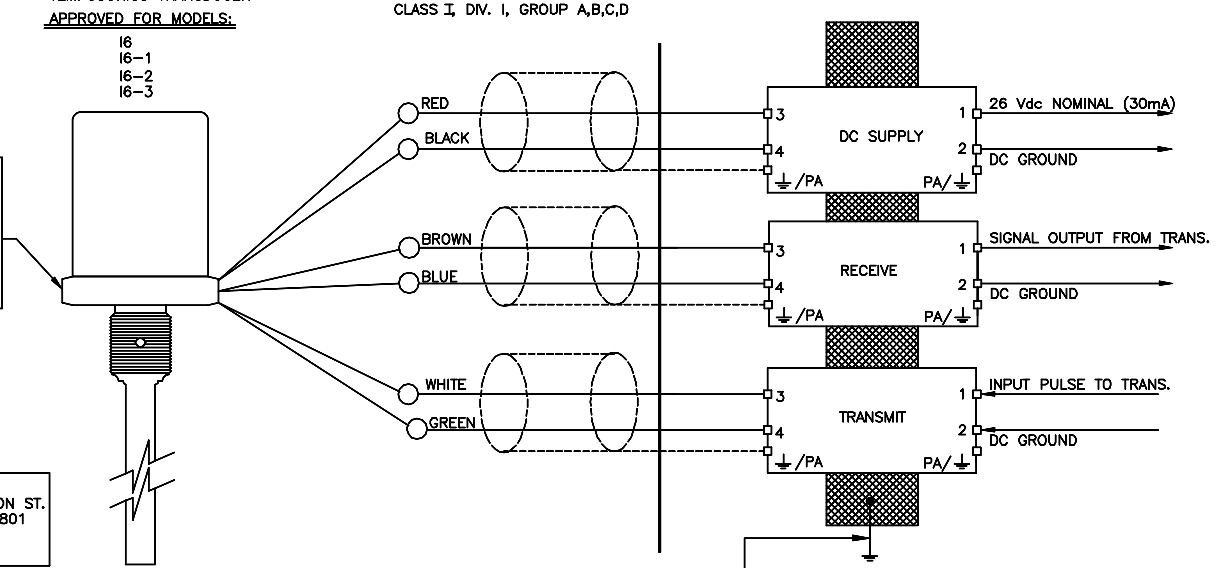
Figure 5.1a
Intrinsically Safe System with MTL Safety Barriers

MTS
TEMPOSONICS TRANSDUCER
APPROVED FOR MODELS:
I6
I6-1
I6-2
I6-3

FRAME OF TRANSDUCER MUST BE CONNECTED TO POWER SUPPLY GROUND (DC GROUND). THERE MUST BE A CONNECTION BETWEEN POWER SUPPLY GROUND AND FRAME OF EQUIPMENT ON WHICH TRANSDUCER IS MOUNTED.(ONE CENTRAL GROUND IS IS DESIRABLE),RESISTANCE BETWEEN THE FRAME OF THE EQUIPMENT (ON WHICH THIS TRANSDUCER IS MOUNTED) AND TRANSDUCER SHALL BE $\leq$ 0.1 OHM.

HAZARDOUS LOCATION
CLASS I, DIV. I, GROUP A,B,C,D

NONHAZARDOUS LOCATION OR APPROVED HAZARDOUS LOCATION
ANY CHANGES IN THIS LOCATION MAY AFFECT INTRINSIC SAFETY.



THIS CONNECTION MUST BE MADE TO DISTRIBUTION PANEL GROUND AND BE LESS THAN 1 OHM TO EARTH GROUND.

BARRIER MANUFACTURERS	ELCON INSTRUMENTS 5834 PEACHTREE CORNERS EAST NORCROSS (ATLANTA), GA. 30092 800-253-5266	MTL INC. 8576 WELLINGTON RD. P.O. BOX 1690 MANASSAS VA. 22110 (703) 361-0111	R. STAHL INC. 150 NEW BOSTON ST. WOBURN MA 01801 800-782-4357

BARRIER MFG.	BARRIER MODEL NUMBER	FUNCTION	Voc VOLTS	Isc mA	Ca MAX. CLASS I, DIVISION 1, GROUPS A, B, C, D	La MAX. CLASS I, DIVISON 1, GROUP A, B, C, D
R. STAHL INC.	9001/01-086-150-10	TRANSMIT	8.6	146.2	5.90	1.70
R. STAHL INC.	9110/01-086-150-10	RECEIVE	8.6	146.2	5.90	1.70
R. STAHL INC.	9001/01-280-100-10	DC SUPPLY	28.0	100.0	0.14	3.60
MTL INC.	110+ OR 710+	TRANSMIT	10.0	200	3.00	0.95
MTL INC.	110+ OR 710+	RECEIVE	10.0	200	3.00	0.95
MTL INC.	128+ OR 728+	DC SUPPLY	28.0	93	0.13	4.02
ELCON INC.	1660-aD-AS-FF	TRANSMIT	7.12	288.5	12	0.5
ELCON INC.	1660-aD-AS-FF	RECEIVE	7.12	288.5	12	0.5
ELCON INC.	1680-bS-P-FF	DC SUPPLY	28.7	94	0.12	4.1
ELCON INC.	MB4/2/8ac OR MB4/4/8ac 8ac	TRANSMIT	12.2	247	1.3	0.5
ELCON INC.	MB4/2/8ac OR MB4/4/8ac 8ac	RECEIVE	12.2	247	1.3	0.5
ELCON INC.	MB4/2/18+	DC SUPPLY	31.8	103.9	0.095	3.5

NOTES:

1. FACTORY MUTUAL RESEARCH CORPORATION APPROVED FOR INTRINSICALLY SAFE CLASS 1, DIVISION 1, GROUPS A, B, C, D.

   USE GENERAL PURPOSE ENCLOSURES MEETING THE REQUIREMENTS OF ANSI/IS 82 IN A HAZARDOUS OR CLASS 1, DIVISION 2, GROUPS A, B, C AND D HAZARDOUS LOCATIONS.

   USE FMRC APPROVED OR NRTL LISTED DUST IGNITION-PROOF ENCLOSURE FOR ENVIRONMENTAL PROTECTION IN CLASS II, DIVSON 2, GROUPS E, F AND G AND CLASS III, DIVSON HAZARDOUS LOCATIONS

2. ELECTRONIC EQUIPMENT CONNECTED TO ASSOCIATED APPARATUS MUST NOT USE OR GENERATE MORE THAN 250 VOLTS RMS.

   CABLE SETS THAT ARE RUN TOGETHER MUST HAVE SUFFICIENT INSULATION TO WITHSTAND 250 VRMS BETWEEN SETS.

3. INSTALLATION DRAWING SHALL BE IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE ANSI/IS 70 ARTICLE 504.
4. THE INTRINSICALLY SAFE FIELD WIRING SHALL BE IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE ANSI/IS 70 AND LOCAL CODES.
5. RECEIVE/TRANSMIT CABLES CONNECTED TO THE BARRIERS SHALL BE LOW CAPACITY CABLES OF 14 pF OR LESS/FOOT (REFERENCE BELDEN 9730, UL 2493) FOR LENGTHS OF 40 TO 200 FEET. WIRE GAUGE SHALL BE 24 AWG OR HEAVIER.
6. WHEN USING THE R. STAHL RECEIVE/TRANSMIT BARRIER (9001/01-086-150-10), THE RECEIVE/TRANSMIT CABLE FOR CABLE LENGTHS OF 200 TO 500 FEET, BELDEN 9182 (UL 2602) TWIN AXIAL SHALL BE USED. THE SHIELD MUST BE GROUNDED ON BOTH ENDS. THE DC SUPPLY BARRIER (R. STAHL 9001/01-280-100-10) WILL HAVE 20 AWG TWISTED WIRES.
7. WHEN USING THE MTL RECEIVE/TRANSMIT BARRIERS (MTL 110+, MTL 710+) THE RECEIVE/TRANSMIT CABLE FOR CABLE LENGTHS OF 200 TO 100 FEET, BELDEN 9182 (UL 2602) TWIN AXIAL SHALL BE USED TWISTED WIRES (SHIELD IS NOT REQUIRED).

   THE SHIELD MUST BE GROUNDED ON BOTH ENDS. THE DC SUPPLY BARRIER (MTL 128+, MTL 728+) WILL HAVE 20 AWG TWISTED WIRES (SHIELD IS NOT REQUIRED).

NO REVISION SHALL BE MADE WITHOUT NOTIFICATION OF THIRD PARTY APPROVAL AGENCY(IES).

REV.	DATE	BY	ECO #	DESCRIPTION
K	8-95	WB	2911	REDRAWN-COMBINED 2 SHTS INTO 1,ADD NEW VENDOR.
J	8-95	WB	2974	CHANGED MODEL NUMBERS: INT-F-0000 TO I6, INT-H-0000 TO I6-3, INT-R-0000 TO I6-2, INT-S-0000 TO I6-1.
H	7-94	RB	2721	ADDED PAGE 2
G	8-92	CW	2330	ADDED RESISTANCE TO NOTE (< 0.1 OHMS)
F	2-91	RB	1982	CHG REVISION NOTE,REVISED CABLE NOTES
E	1-91	RB		REDRAWN ON CAD FORMERLY IS-1020
D	3-87			ADDED APPROVED FOR TABLE
C	4-86			ADDED OPTIONAL MTL NUMBERS
B	6-85			ADDED GROUP,DIV, AND CLASS NOTES
A				ADDED CABLE NOTES & MISC NOTES

UNLESS OTHERWISE SPECIFIED:
.XX = ± .01
.XXX = ± .005
ANGULAR = ± 1°
REMOVE BURRS AND SHARP EDGES .015 MAX
DIM. LIMITS HELD AFTER PLATING OR CONVERSION COATING
DRILL DEPTHS ARE TO FULL DIAMETER
TAP DEPTHS ARE MINIMUM FULL THREADS

MATERIAL
FINISH
DO NOT SCALE DRAWING

DRAWN R.BARR | DATE 7/15/94
DOCUMENT OWNER D.JOHNSON
PRODUCT LINE TEMPOSONICS
SCALE — | DRAWING SIZE C
SHEET 1 OF 1

MTS
SYSTEMS CORPORATION
SENSORS DIVISION
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27709

TITLE MTS TEMPOSONICS TRANSDUCER AND SAFETY BARRIER SELECTION

DWG NO. 650512 | REV K

5.2 Analog Systems -- Power Supply and Sensor Connections

SYSTEM
• Temposonics Position Sensor
• Analog Output Module w/Strain-relief Connectors
• 26 Vdc Power Supply
• ±15 Vdc Power Supply

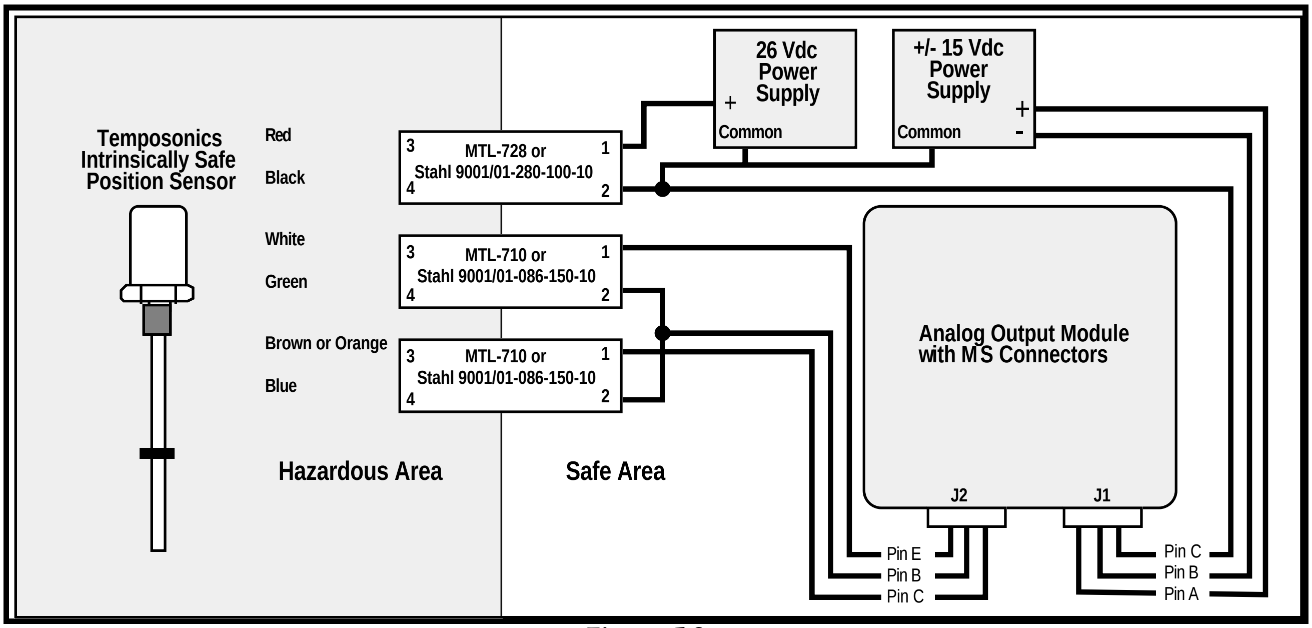


Figure 5.2
Analog Output Module w/ Strain-relief Connectors

SYSTEM
• Temposonics Position Sensor
• Analog Output Module w/MS-Style Connectors
• 26 Vdc Power Supply
• ±15 Vdc Power Supply

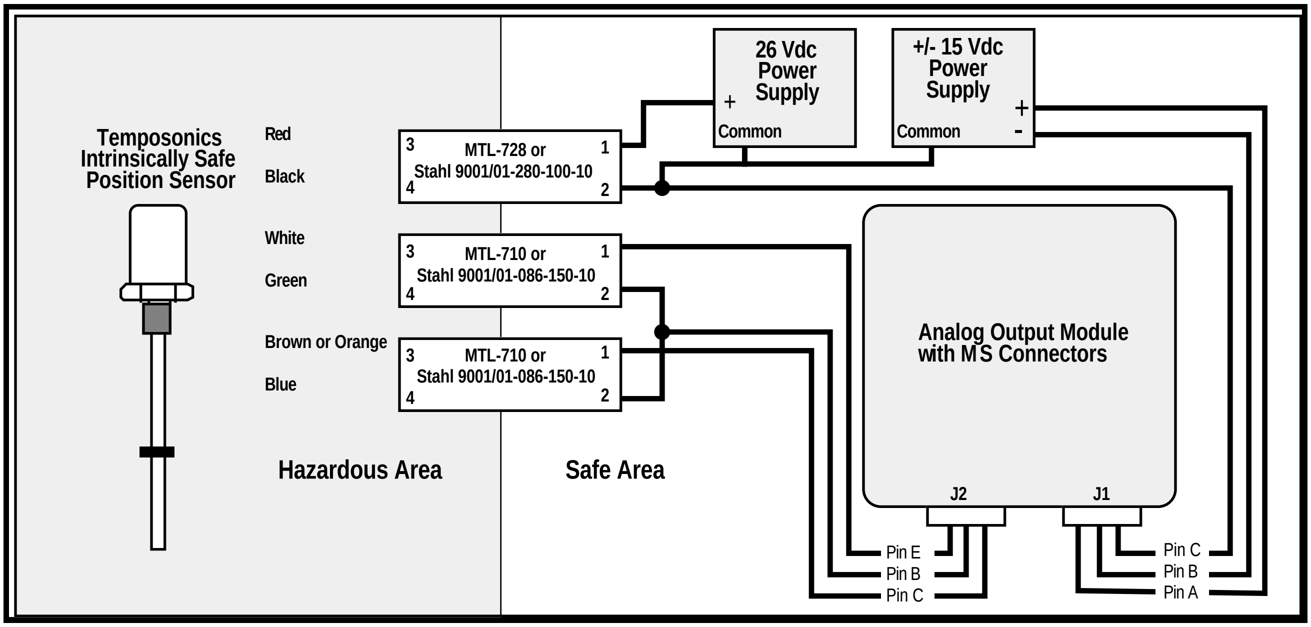


Figure 5.3
Analog Output Module w/MS Style Connectors

SYSTEM
• Temposonics Position Sensor
• Analog Output Module w/Strain-relief Connector and 24 Vdc power supply option
• 26 Vdc Power Supply

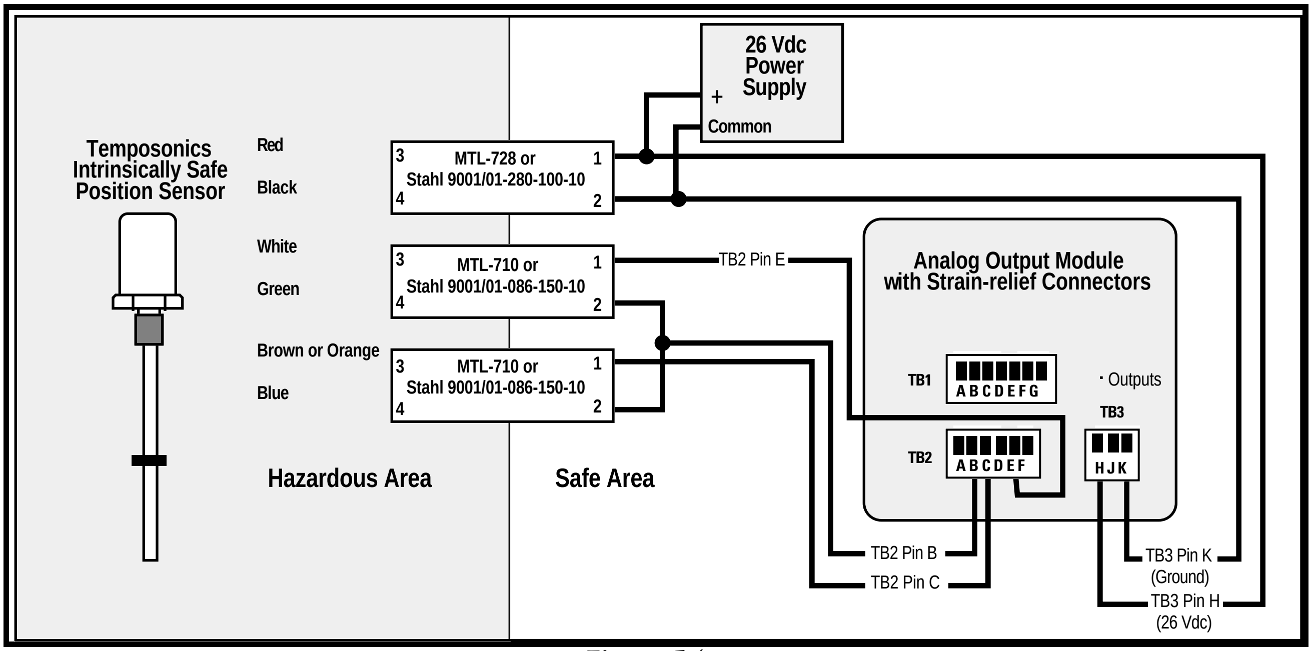


Figure 5.4

Analog Output Module w/ Strain-relief Connectors and 24 V Power Supply Option

SYSTEM
• Temposonics Position Sensor
• Analog Output Module w/MS-Style Connectors and 24 Vdc power supply option
• 26 Vdc Power Supply

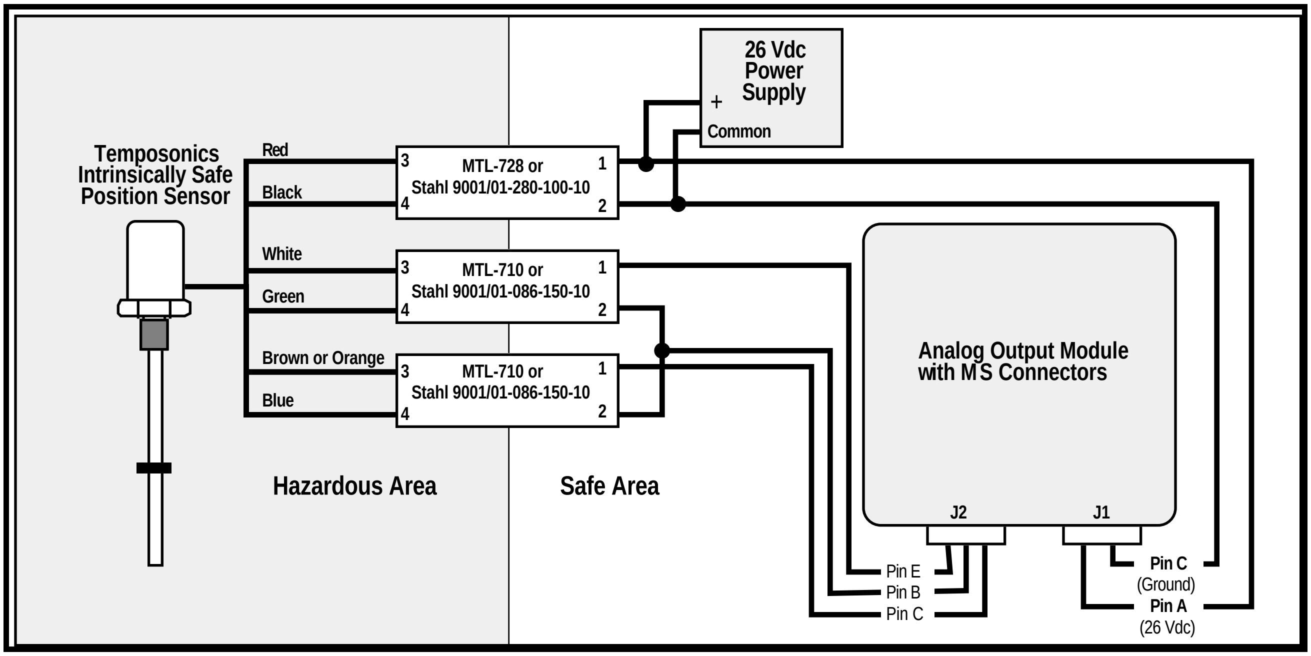


Figure 5.5

Analog Output Module w/MS Style Connectors and 24 V Power Supply Option

5.2.1 Analog Output Module (AOM) Output Connections (TB1)

Table 5A Standard AOM

Strain Relief Connection	*MS Connector Pin Designation*	*Function*
TB1		
A	D	(+) Displacement Output
B	E	(-) Displacement Output Return
C	n/a	n/a
D	n/a	n/a

Table 5B AOM w/Velocity Output Option

Strain Relief Connection	*MS Connector Pin Designation*	*Function*
TB1		
A	D	(+) Displacement Output
B	-	(-) Displacement Output Return
C	E	(+) Velocity Output
D	-	(-) Velocity Output

Table 5C AOM w/Dual Channel Option

Strain Relief Connection	*MS Connector Pin Designation*	*Function*
TB1		
A	D	**Channel 1** (+) Displacement Output
E	E	**Channel 2** (+) Displacement Output
C	n/a	n/a
D	n/a	n/a

5.3 Digital Systems -- Power Supply and Sensor Connections

SYSTEM
• Temposonics Position Sensor
• Digital Interface Box
• 26 Vdc Power Supply
• Power Supplies: + 15, - 15, and 5 Vdc

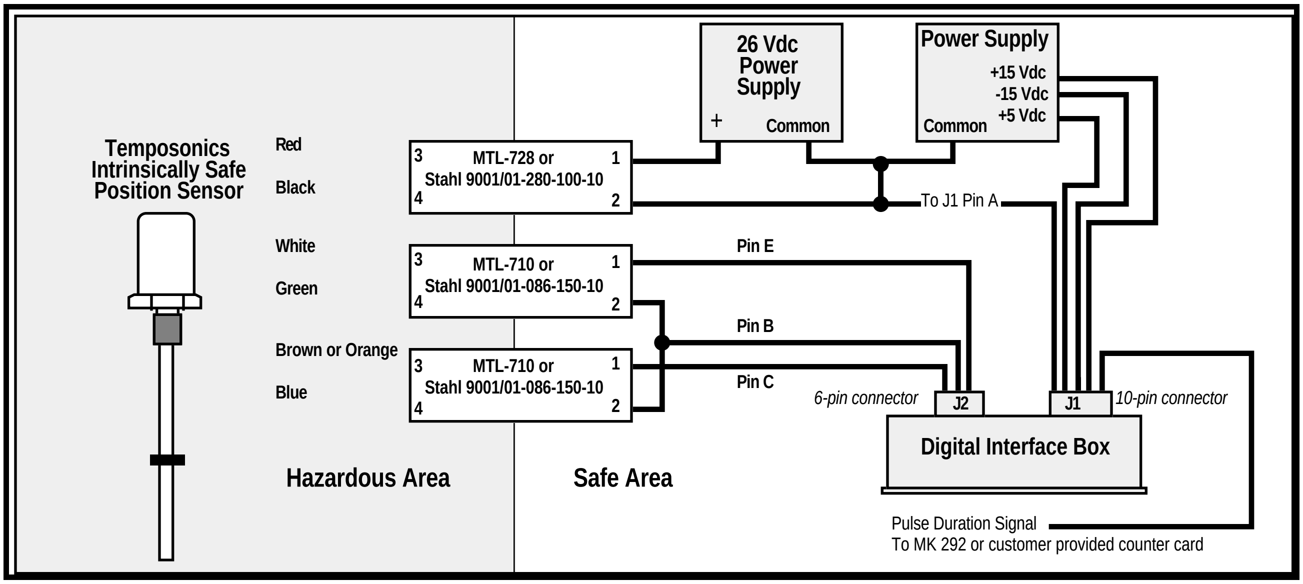


Figure 5.6
Digital System

5.3.1 Digital Systems -- Digital Interface Box J1 Connections

Table 5D Digital Interface Box J1 Connections

J1/Pin #	Function
A	DC Common
B	- 15 Vdc Power
C	+ 5 Vdc Power
D	(-) External Interrogation Pulse
E	(+) External Interrogation Pulse
G	(+) Gate Output
H	+ 15 Vdc Power
J	Case Ground
K	(-) Gate Output

5.4 MK 292 Digital Output Module Connections

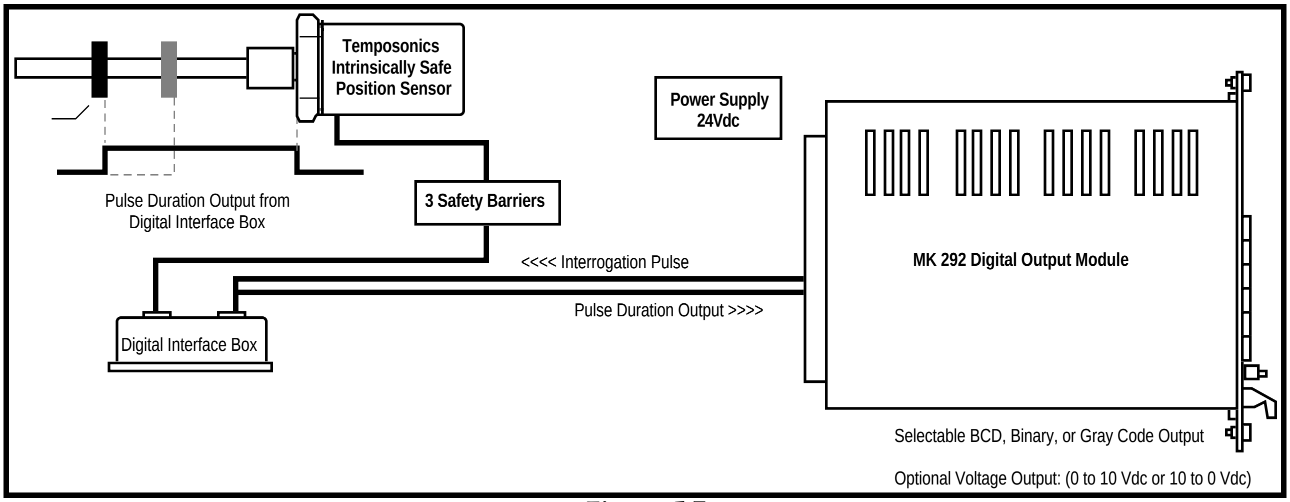


Figure 5.7
Typical System Configuration --
Intrinsically Safe Position Sensor, Digital Interface Box,
and MK 292 Module

NOTICE:

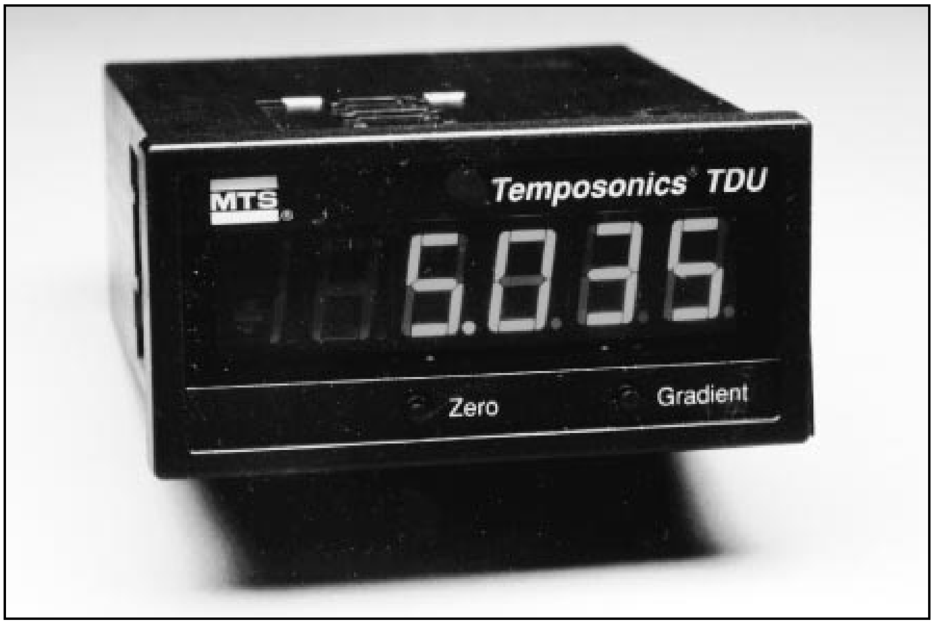
Refer to document number 550414 (MK 292 Digital Output Module Installation Manual and Ordering Guide) for details on the installation, wiring, and programming of the MK 292 Module.

P R O D U C T   S P E C I F I C A T I O N

TEMPOSONICS®

Temposonics® Display Unit (TDU) Model TDU-100

Features:
- **Zero Reset (along entire stroke)**
- **Scaled Outputs**
  - **Inches**
  - **Millimeters**
  - **Centimeters**
  - **Meters**
- **Compatible with Temposonics II & Temposonics LP**
- **Large 5 1/4 digit LED characters**



The Temposonics Display Unit (TDU) provides a large, clear, LED readout of accurate measurement data. The TDU is ideal for use in applications where immediate visual verification of position is required, such as plastic and woodworking applications.

The TDU is designed to work with both the Temposonics II and Temposonics LP transducers with Start/Stop output. Together, the TDU and Temposonics transducers provide a highly accurate, reliable, and easy to use position display system.

If you want to find out more about the TDU or any of the other Temposonics products, please call MTS Sensors Division at (800) 633-7609.

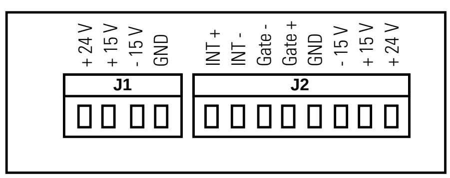
Specifications

Temposonics Display Unit (Model TDU-100)

Parameter	Specifications
Supply Voltage:	• w/Temposonics II: ± 15 Vdc
	• w/Temposonics LP: + 20 to 24 Vdc
Sensor Product Life:	• Active Sensing Element - 4 x 106 MTBF
Display Electronics Enclosure:	• Drip, dust and rust resistant
Non Linearity (transducer):	• Temposonics II: < ±0.05% F.S. or ±0.0001 inch (±0.0025 mm)*
	• Temposonics LP: ± 0.1% of F.S., minimum of ± 0.004 in. (0.10 mm)*
Repeatability (transducer):	• ± 0.001% of full stroke, or ± 0.0001 in. (± 0.0025 mm)
Measuring Range (transducer):	• Temposonics II: Up to 25 feet
	• Temposonics LP: Up to 48 inches
Operating Temperature:	• 32 to 158°F (0 to 70°C)
Output:	• 5 1/4 digit LED display; Outputs selected via internal dip switch
Inches: 199.995	• 0.005 in.
Millimeters: 5080.00	• 0.1 mm
Centimeters: 508.00	• 0.01 cm
Meters: 5.0800	• 0.0001 m
Zero Reset:	• Available on front of display panel

Specifications are subject to change without notice. Contact MTS for verification of specifications critical to your needs.
** Measurements are independent Best Straight Line (BSL)*

Connections



For more detailed literature on Temposonics products, or to talk with an MTS representative, call toll free.

1-800-633-7609

MTS®

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Sensors Division
3001 Sheldon Drive
Cary, North Carolina 27513
Telephone: 800-633-7609
Fax: 919-677-0200

MTS Sensor Technologie GmbH and Co.
Auf dem Schüffel 9
D-58513 Ludensheid
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Sensors Division

Temposonics® Display Unit (TDU)

User's Manual

P/N 550260 Revision C

TABLE OF CONTENTS

GENERAL INFORMATION

MTS Phone Numbers	
To place orders:	800-633-7609 or 919-677-0100
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1 INTRODUCTION

The Temposonics Display Unit (TDU) provides a large, 5 1/4 digit, LED readout of accurate measurement data. It is ideal for use in applications where immediate visual verification of position is required, such as plastic and woodworking applications.

The TDU is designed to function with Temposonics LH, Temposonics II, and Temposonics LP position sensors with START/STOP output. All communication between the display and transducer is transmitted via RS422 Start/Stop protocol. Together, the TDU and Temposonics sensors provide a highly accurate, reliable, and easy to use position display system.

This document identifies the performance specifications, set-up procedures and wiring configurations.

2 SPECIFICATIONS

Parameter	Specification
Supply Voltage:	• w/Temposonics LH: + 15 Vdc @ 250 mA or +20-24 Vdc @ 250 mA • w/Temposonics II: ± 15 Vdc (bipolar, ±10%, 250 mA) • w/Temposonics LP: +15 Vdc @ 250 mA or 20- 24 Vdc @ 250 mA
Sensor Product Life:	Active Sensing Element: 4x 10^6 MTBF
Display Enclosure:	Drip, dust and rust resistant
Non-linearity: (transducer)	• Temposonics LH: ≤ ± 0.05% of full stroke or ≤ ± 0.002 in. (± 0.05 mm) * • Temposonics II: ≤ ± 0.05% of full stroke or ≤ ± 0.002 in. (± 0.05 mm) * • Temposonics LP: ± 0.1% of F.S., minimum of ± 0.004 in. independent BSL
Repeatability: (transducer)	±0.001% of full stroke, or ±0.0001 in. (± 0.0025 mm)
Resolution:	• 0.005 in. (standard) • 0.001 in. available, contact MTS for details **NOTE:** *Resolution for stroke lengths beyond 199.999 inches is reduced to 0.01 in. due to 5 1/4 digit display limitation.*
Measuring Range: (transducer)	• Temposonics LH: up to 200 inches (standard) • Temposonics II: Up to 200 inches (standard) • Temposonics LP: Up to 60 inches **NOTE:** *Temposonics LH and Temposonics II sensors are available up to 300 inches, however the resolution will be reduced to 0.01 in.*
Operating Temperature	32 to 158°F (0 to 70°C)
Output:	5 1/4 digit LED display
Inches: 199.999	*0.001 inches*
Millimeters: 5080.0	*0.1 millimeters*
Centimeters: 508.00	*0.01 centimeters*
Meters: 5.0800	*0.0001 meters*
	• **NOTE:** *Scaling is selectable via internal dip switches*

Zero Reset:	Available on front of panel
Gradient Input:	Available on front of panel

* Whichever is greater

3 INSTALLATION KIT

Each TDU (Model # TDU100) is provided with an installation kit for mounting. Installation kits includes:

- Mounting brackets and screws (Part No. 560488)
- Front panel gasket (Part No. 560496)

The TDU comes complete with mounting brackets , screws and gasket, these items may also be ordered separately

Accessories that can be ordered separately, at additional cost, are as follows:

- NEMA 4 Environmental Enclosure (Part No. 251188)
- 20 Vdc Power Supply (Part No. 380045)
- ±15 Vdc Power Supply (Part No. 380017)

4 SCALING THE OUTPUT

The output is selectable via dip switch settings to provide an output scaled for inches, millimeters, centimeters or meters. There are four dip switches, positioned as indicated in Figure 1. To gain access to these switches you must pull off the J1 and J2 terminal blocks and remove the rear cover that is held in place by 4 screws. Position the switches as indicated in the table below to set the desired scaling. Replace the rear cover and the J1 and J2 terminal blocks immediately after setting scaling to prevent any foreign debris from entering the enclosure and potentially interfering with the performance of the TDU.

	*SW1**	*SW2*	*SW3*	*SW4***
Inches (default)	**ON**	**ON**	**ON**	**ON**
Millimeters	**ON**	**OFF**	**ON**	**ON**
Centimeters	**ON**	**ON**	**OFF**	**ON**
Meters	**ON**	**OFF**	**OFF**	**ON**

* *When SW1 is OFF the Gradient Mode and Zero functions are disabled.*
** *SW4 is reserved for future use.*

5 WIRING

Wiring from the transducer terminates at the TDU on terminal block J2 (Refer to Figure 1, below). Tables 5.1, 5.2, 5.3, below, illustrate the appropriate connections for wiring the Temposonics LH, Temposonics II, or Temposonics LP, to the TDU and power supply (i.e., 15 Vdc, ±15 Vdc, or 20-24 Vdc power supply).

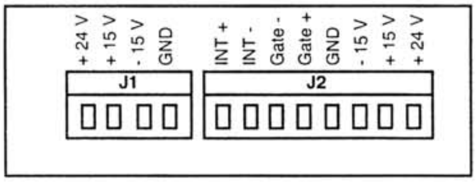

Figure 1
Rear Panel of TDU w/Terminal Blocks

5.1 TDU w/Temposonics LH

w/+15 Vdc or + 20 - 24 Vdc Power Supply (See Notes 1 & 2)				
TDU Pin #	***Functional Description***	***6-Conductor Integral Cable***	***Striped Wire RB / RC Extension Cable***	***Solid Wire RB / RC Extension Cable***
J1-1	-	-	-	-
J1-2	+ 15 Vdc (Note 1)	Customer Provided	Customer Provided	Customer Provided
J1-3	+ 20 - 24 Vdc (Note 2)	Customer Provided	Customer Provided	Customer Provided
J1-4	GND	Customer Provided	Customer Provided	Customer Provided
J2-1	INT +	Yellow	White/Gray Stripe	Yellow
J2-2	INT -	Green	Gray/White Stripe	Green
J2-3	Gate -	Gray	White/Orange Stripe	Gray
J2-4	Gate +	Pink	Orange/White Stripe	Pink
J2-5	GND	White Drain Wire	White/Blue Stripe Blue/White Stripe	White Brown
J2-6	-	-	-	-
J2-7	+ 15 Vdc (Note 1)	Red	White/Green Stripe	Red
J2-8	+ 20 - 24 Vdc (Note 2)	Red	White/Green Stripe	Red

NOTES:
1. Use J1-2 if power supply is +15 Vdc, this pin is not used if using a 20-24 Vdc supply.
2. Use J1-3 if using a 20-24 Vdc power supply, this pin is not used if using a 15 Vdc supply.

5.2 TDU w/Temposonics LP

w/+15 Vdc Power Supply			w/ 20 - 24 Vdc Power Supply		
TDU Pin #	***Functional Description***	***Sensor Wire Color***	***TDU Pin #***	***Functional Description***	***Sensor Wire Color***
J1-1	-	-	J1-1	20 to 24 Vdc	Customer Provided
J1-2	+ 15 Vdc.	Customer Provided	J1-2	-	-
J1-3	-	-	J1-3	-	-
J1-4	GND	Customer Provided	J1-4	GND	Customer Provided
J2-1	INT +	Orange	J2-1	INT +	Orange
J2-2	INT -	Yellow	J2-2	INT -	Yellow
J2-3	Gate -	Blue	J2-3	Gate -	Blue
J2-4	Gate +	Green	J2-4	Gate +	Green
J2-5	GND	Black & Shield	J2-5	GND	Black & Shield
J2-6	-	Not Used	J2-6	-	-
J2-7	+15 Vdc	Red	J2-7	-	-
J2-8	-	Not used	J2-8	20 to 24 Vdc	Red

5.3 TDU w/Temposonics II & ±15 Vdc Power Supply

TDU Pin #	***Functional Description***	***Striped Leads***	***Solid Leads***
J1-1	-	-	-
J1-2	+ 15 Vdc;	Customer Provided	Customer Provided
J1-3	- 15 Vdc;	Customer Provided	Customer Provided
J1-4	GND	Customer Provided	Customer Provided
J2-1	INT +	White/Gray Stripe	Yellow
J2-2	INT -	Gray/White Stripe	Green
J2-3	Gate -	White/Orange Stripe	Gray
J2-4	Gate +	Orange/White Stripe	Pink
J2-5	GND	White/Blue Stripe Blue/White Stripe	White Brown
J2-6	-15 Vdc	Green//White Stripe	Blue
J2-7	+15 Vdc	White/Green Stripe	Red
J2-8	-	-	-

NOTES:
1. Customer Provided Cable
2. Your Temposonics II transducer may have a cable with striped leads or with solid color leads. Both cables are identified in the wiring chart and have identical performance specifications. Solid color leads are now standard (since February, 1994).

6 ZERO

Press the left push button on the front panel of the TDU (labeled "Zero", Figure 2) to set the display value to "0". Dip Switch 1 (refer to Figure 3 for dip switch locations) when set to OFF, disables this function. The default setting for Dip Switch 1 is ON.

a.) To enter a **Permanent ZERO**, press and hold the left (ZERO) push button. As soon as the display reads "0.000", press the right push button. Release both push buttons.

b.) To enter a **Relative ZERO**, press and release the left (ZERO) push button. To recover the permanent zero setting, press and release the ZERO push button once again.

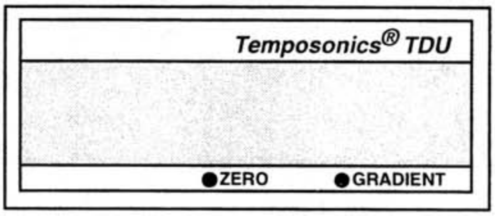

Figure 2
Front panel/TDU, Zero and Gradient Push-buttons

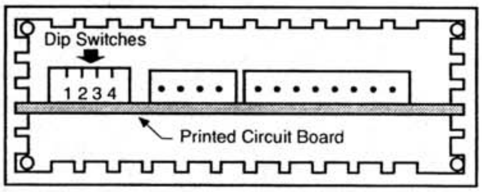

Figure 3
Rear View of TDU w/Cover Removed

7 GRADIENT

The Gradient is unique for each transducer manufactured. It represents the inverse of the velocity of the return pulses that travel along the waveguide of the transducer (measured in microseconds per inch). Although this velocity is very consistent from transducer to transducer and is extremely repeatable for a particular transducer, there are slight variances. To compensate for these slight variances, the TDU offers a Gradient Mode which allows you to precisely program the gradient of a particular transducer into the TDU. The following steps define the procedure for setting the gradient. The gradient will be displayed in "µs/inch" (microseconds per inch) if dip switches SW2 and SW3 are ON prior to entering the gradient mode. Otherwise, the gradient is displayed in "m/s" (meters per second).

Gradient conversion
To convert gradient from microseconds per inch to meters per seconds, the following formula applies:

25400/gradient (µs/in.) = m/s

Example:
Gradient = 9.050 µs/in.
25400/9.05 = 2806.62 m/s

1. Ensure that Dip Switch 1 (refer to Figure 3 for switch location) is set to ON (If Dip Switch 1 is set to OFF, this function will be disabled). Press and hold the right push button (labeled "Gradient") on the front panel of the TDU for about 6 seconds. The TDU will respond by displaying the current Gradient value

2. Release the Gradient push button

3. Use the right or left push buttons (labeled Gradient and Zero, respectively) to increase or decrease the gradient value. The Gradient for each Temposonics transducer is identified on the label attached to the transducer.

4. To exit the Gradient Mode and to set the new Gradient value, press both front panel push buttons simultaneously. Release both push buttons as soon as the screen goes blank. The TDU will respond by returning to its normal operating mode.

8 OFFSET ADJUST MODE

The Offset Adjust Mode allows you to enter an offset in the displayed output. To enter this mode, position the transducer's magnet at the desired location following the steps below:

1. Press and hold the right push button (labeled Gradient) for approximately 6 seconds. The TDU will respond by showing the gradient currently in use. (SW1 = OFF disables this function).

2. While depressing the right push button (Gradient), press and release the left push button (Zero). The display will go blank.

3. Release the right push button (Gradient). The display will flash the magnet position. This indicates the Offset Adjust Mode is active.

4. Use the right or left push button until the desired position value is displayed. (Note that if either push button is depressed for approximately 20 seconds, a rapid value increment or decrement will occur).

5. To exit the Offset Adjust Mode, press both push buttons simultaneously. Release both push buttons as soon as the display goes blank. The TDU will respond by returning to its normal operating mode.

IMPORTANT NOTES:

1. Span should not exceed ±199.995 in.

2. The TDU will display 'E7' if it receives no input from the Temposonics transducer. This could mean either the transducer is incorrectly wired to the TDU, the transducer is malfunctioning, or that the magnet has exited the active area of the transducer. If the E7 code is displayed because the magnet is no longer in the active zone of the transducer, when the magnet returns to the active zone, the TDU will resume normal operation.

9 TDU DIMENSIONS

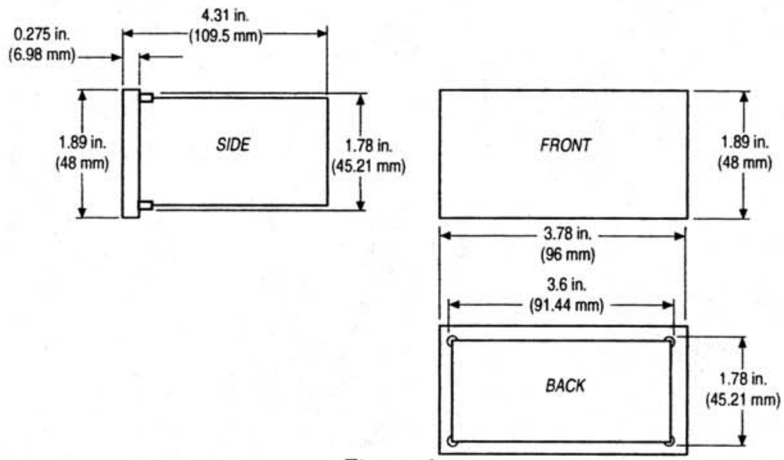

Figure 4
TDU Dimensions

ADDENDUM A

Subject: Installing Optional NEMA 4 Enclosure for TDU

Part No. for NEMA 4 Enclosure: 251188

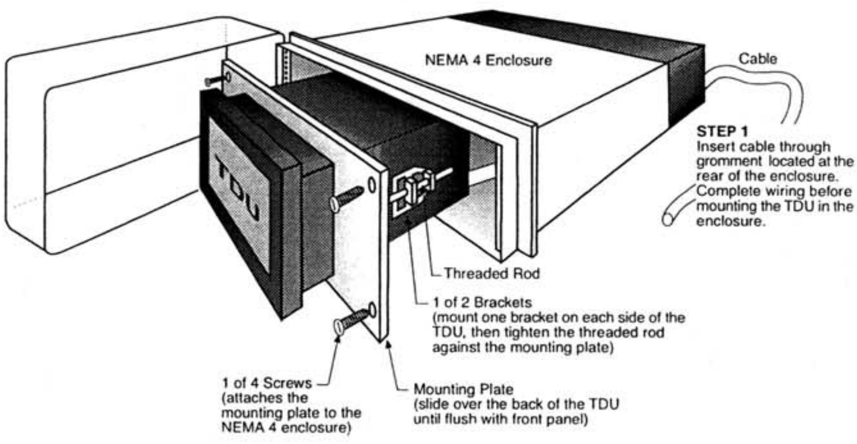

Figure 5
NEMA 4 Enclosure

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National FLUID POWER Association® MEMBER

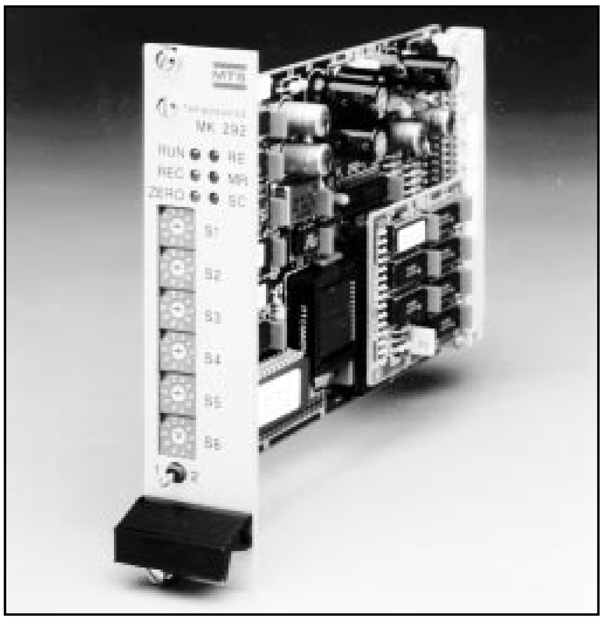
PRODUCT SPECIFICATION

MTS®

TEMPOSONICS®

Temposonics® Digital Output Module
Model MK292

Features:
- **Microprocessor-controlled**
- **External synchronization**
- **Output selections:**
  - ***- BCD***
  - ***- Natural Binary***
  - ***- Gray Code***
- **Program settings:**
  - ***- Zero point***
  - ***- Resolution***
  - ***- Active stroke length***
  - ***- Output orientation***
- **Error feedback**
- **Noise rejection**
- **Data ready/Data hold**
- **Master/Slave opera-**



The Temposonics MK292 Digital Output Module provides an interface between a Temposonics position sensor and a system controller. The selection of displacement outputs from the MK292 allows almost universal compatibility; they include: BCD, Binary, and Gray Code.

'DATA READY' and 'ERROR' feedback, as well as logic inputs (DATA HOLD, EXTERNAL START, MASTER/SLAVE, and TRI-STATE) are standard with the MK292. If required, an optional sub-board assembly provides an analog output (range: 0 to 10 Vdc or 10 to 0 Vdc).

Two mounting configurations are available (see above photograph). Both are designed for installation in a standard 19 inch mounting rack. The module version (left) provides a thermal shield against other electronic components and mechanical protection.

Connections to the MK292 from the position sensor and other sources are made via a 64-pin DIN edge connector (an optional 64-pin card holder is also available).

The format of the input signal from the Temposonics position sensor, and attainable system resolution, is determined by the type of position sensor selected:

1) Temposonics II
- *w / Digital Personality Module*
  - Output: Pulse-width modulated
  - Resolution: 0.0002 in. (0.005 mm)
- *w / RS422 Personality Module*
  - Output: Start/Stop
  - Resolution: 0.002 in. (0.05 mm)

2) Temposonics LP
- Output: Start/Stop
- Resolution: 0.002 in. (0.05 mm)

Specifications

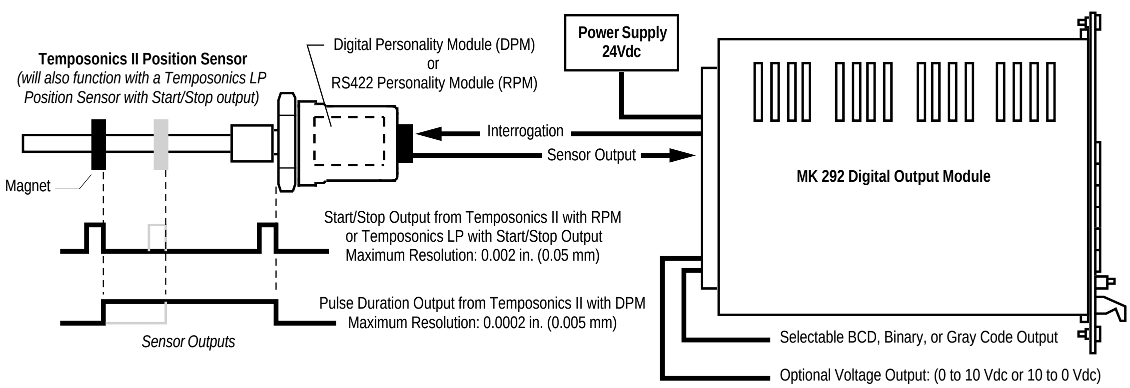
Temposonics Digital Output Module (Model MK292)

Parameter	Specifications
Supply Voltage:	• 24 Vdc (- 15%/+ 20%)
Input Requirement:	• Temposonics II with integrated Digital Personality Module (DPM) -- Pulse-width modulated (PWM) • Temposonics II with integrated RS422 Personality Module (RPM) -- Start/Stop output • Temposonics LP with Start/Stop output
Output Format:	• Selectable: BCD, Binary, or Gray Code; 24 bits data output and 1 parity bit
Resolution:	• 0.002 in. (0.05 mm) when using Temposonics II position sensor with RS422 Personality Module (RPM) or Temposonics LP position sensor • 0.0002 in. (0.005 mm) when using Temposonics II position sensor with Digital Personality Module (DPM)
Update Frequency:	• Stroke and resolution dependent
Optional Voltage Output:	• 0 to 10 Vdc or 10 to 0 Vdc (with additional sub-print AK 294)
Programming Parameters:	• Zero, Resolution, Stroke Length, Measuring Direction
Connection:	• 64-pin edge connector (DIN 41612); Optional 64-pin card holder available (Part No. 370292)
Cable Requirement:	• 8 x 24 AWG, twisted pairs, shielded (Belden 8104 recommended)
Maximum Cable Length:	• 500 meters
Dimensions:	• 19 in. standard European board (Front panel: 30.2 x 128.4 mm) • 19 in. module for rack mounting (Front panel: 50.4 x 128.4 mm)

Specifications are subject to change without notice. Contact MTS for verification of specifications critical to your needs.

** Measurements are independent Best Straight Line (BSL)*

System Configuration



For more detailed literature on Temposonics products, or to talk with an MTS representative, call toll free.

1-800-633-7609

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MTS®

Temposonics®

Position Sensors

MK292 Digital Output Module

Users Manual

0797 550414 Revision B

GENERAL INFORMATION

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Table of Contents

1. Introduction to the MK292 Digital Output Module

The MK292 Digital Output Module provides an interface between a Temposonics position sensor with a pulse-width modulated or start/stop output and a system controller. A selection of outputs from the MK292 (BCD, binary, or Gray Code) gives this device nearly universal compatibility.

The MK292 is compatible with many Temposonics position sensors, as follows:

Compatible Position Sensors:

- SE-based Temposonics LP sensor with start/stop output
- Temposonics II sensors with a pulse-width modulated or start/stop output
- Temposonics L Series sensors with a pulse-width modulated or start/stop output

In addition to position data, the MK292 generates logic outputs: DATA READY and ERROR; and logic input: DATA HOLD. An optional sub-board assembly provides an analog output for recording purposes (output range: 0 to 10 Vdc or 10 to 0 Vdc).

The MK292 can be configured as either a rack-mountable card or module that can be installed in a standard 19 inch mounting rack.

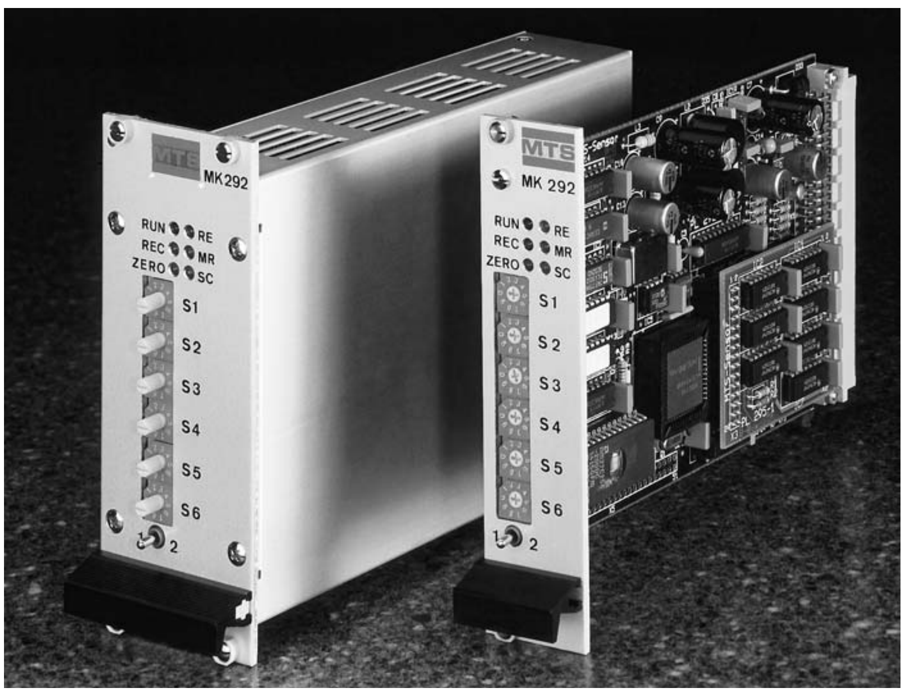


Figure 1-1
MK292 (Module version, left; card version, right)

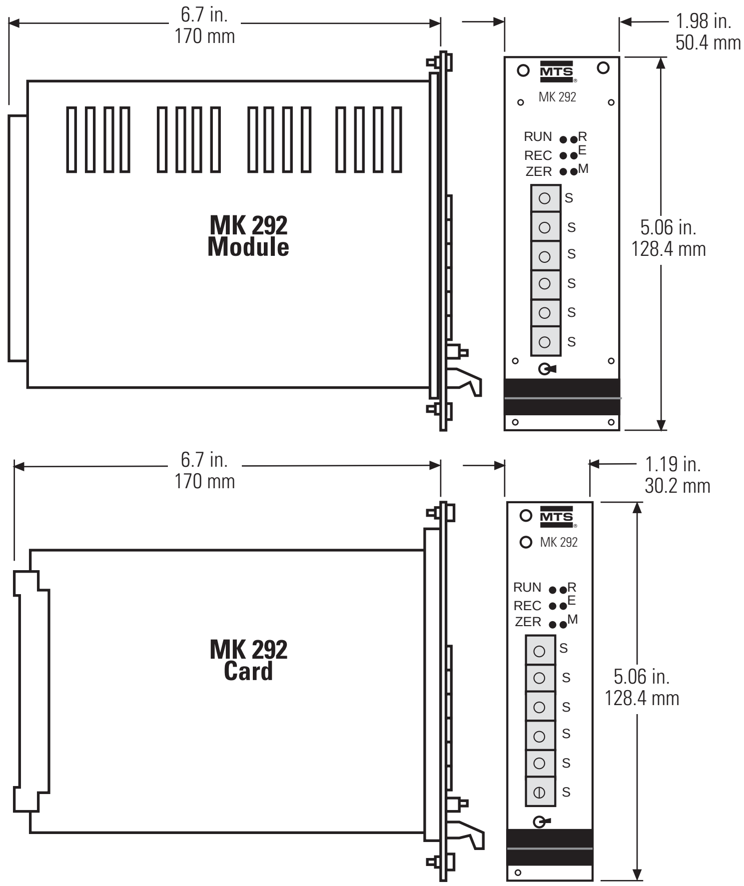


Figure 1-2
MK292 Digital Output Module Dimensions

1.1 System Configuration

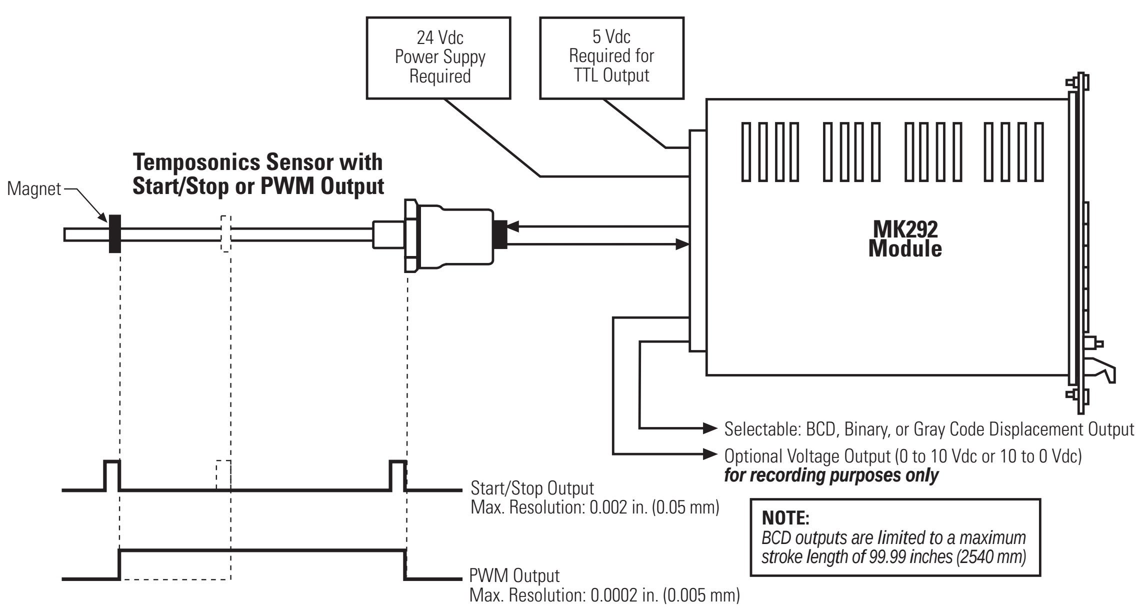


Figure 1-3
Typical System Configuration

2. Specifications

2.1 MK292 Digital Output Module Specifications

Parameter	***Specification***
Input Voltage:	24 Vdc (-15%/+20%); Ripple: < 5% **NOTE:** ***An additional 5V power supply is required for the optional TTL level outputs; dual power supply (24/5 Vdc) is available from MTS, P/N 380066***
Current Draw:	250 mA maximum
Input Requirement:	SE-based Temposonics LP with start/stop output* Temposonics II with PWM or start/stop output Temposonics L Series with PWM or start/stop output*
Output Format: (Selectable):	Up to 24 bit: • BCD *(maximum stroke length with BCD output scaled in millimeters is 7500 mm. When utilizing inches, strokes may be up to 300 inches)* • Natural Binary • Gray Code
Resolution:	0.002 in. (0.05 mm) with start/stop input 0.0002 in. (0.005 mm) with PWM input
Update Frequency:	Stroke and resolution dependent
Optional Analog (Recorder) Output :	Range: -10 to +10 Vdc *(used for recording; option board required - must be specified upon initial order)* 12 bit resolution 5mv ripple Fully adjustable
Programming Parameters:	Zero Resolution Stroke Length Measuring Direction Analog Output *(used for recording; option board required - must be specified upon initial order)*
Operating Temperature:	0 to 60°C (32 to 140°F)
Connection:	64 pin edge connector (DIN 41612; provided with circuit card)
Cable Requirements:	8 x 24 AWG, twisted pairs, shielded low capacitance cable (BELDEN 8105 or equivalent) w/appropriate number of conductors for sensor used
Maximum Cable Length:	Sensor with RS422 output: 500 meters (1640 ft.) Sensor with PWM output: 152.4 meters (500 ft.)
Dimensions:	MK292 Card, Front Panel: 30.2 x 128.4 mm (1.19 x 5.06 in.) MK292 Module, Front Panel: 50.4 x 128.4 mm (1.98 x 5.06 in.)

** When using the MK292 with a Temposonics LA or LP sensor, please contact Applications Engineering.*

Specifications are subject to change without notice. Consult MTS for verification of specifications critical to your application.

2.2 Temposonics Position Sensor Specifications

For detailed specifications and installation requirements for the position sensors, refer to the appropriate document, as follows:

- Temposonics II Sensor Installation and Instruction Manual (P/N 550055)
- SE-based Temposonics LP Installation Guide (P/N 550582)
- Temposonics L Series/Digital Product Specification (P/N 550539)

> **NOTE (Zero Points):**
> *Before ordering an MK292 with a Temposonics LA or LP sensor, consult an MTS Sensors Division Applications Engineer for details regarding the positioning of the sensor's ZERO point.*

Parameter	***Specification***
Input Voltage:	Powered from MK292 Module
Stroke Length:	Temposonics II: Up to 300 inches (7620 mm) SE-based Temposonics LP: Up to 48 inches (1219 mm) Temposonics L Series: Up to 120 inches (3048 mm)
Non-linearity:	Temposonics II: < ± 0.05% of full scale or ± 0.002 inch (±0.05 mm), whichever is greater SE-based Temposonics LP: ± 0.1% of full scale or ± 0.004 in. (± 0.10 mm), whichever is greater Temposonics L Series: 0.03% of full scale
Repeatability:	± 0.001% of full scale or ± 0.0001 inch (± 0.002 mm), whichever is greater
Operating Temperature:	Head Electronics: - 40 to 150°F (- 40 to 66°C) Sensor Rod: - 40 to 185°F (- 40 to 85°C)
Operating Pressure:	Temposonics II Rod-Style Sensors: 3000 psi continuous, 8000 psi static typical Temposonics L Series Rod-Style Sensors (Model LH): 5000 psi continuous, 10,000 psi static
Outputs (absolute):	Start/stop or PWM configured for ***external*** interrogation
Mounting Distances:	Sensor with RS422 output to MK292: 500 meters (1640 ft.) Sensor with PWM output to MK292: 152.4 meters (500 ft.) MK292 to PLC: 25 meters (82 ft.)

Specifications are subject to change without notice. Consult MTS for verification of specifications critical to your application.

3. System Components

3.1 MK292-Compatible Temposonics Position Sensors

To interface with the MK292, a start/stop or pulse-width modulated output (see figure 3.1) is required from the Temposonics position sensor. The MK292 will convert these signals into a parallel BCD, Gray Code, or binary output.

COMPATIBLE SENSORS

3.1.1. Temposonics Position Sensor with Start/Stop Output

Temposonics L Series and LP position sensors provide a direct RS422 compatible start/stop output. Temposonics II position sensors require an RS422 Personality Module (RPM), installed in the sensor head, to produce a start/stop output.

3.1.2. Temposonics Position Sensor with Pulse-Width Modulated (PWM) Output

Temposonics L Series position sensors provide a direct pulse-width modulated output. Temposonics II position sensors require a Digital Personality Module (DPM) to generate a pulse-width modulated output. The DPM is installed in the head of the sensor's electronics enclosure.

When using a Temposonics sensor with a PWM output, ***"external interrogation"*** is required to interface with the MK292. External interrogation is an option selected at the time of order and is pre-set at the factory.

3.1.3. Temposonics Position Sensor with Synchronous Operation (External Interrogating)

In synchronous operation, an interrogation pulse is supplied to the position sensor from the MK292 module. After supplying the interrogation pulse, the MK292 waits for the sensor's return pulse, then ends the cycle. The time between the launching of the interrogation pulse and the receipt of the return pulse is proportional to the distance between the null or zero position and the movable magnet.

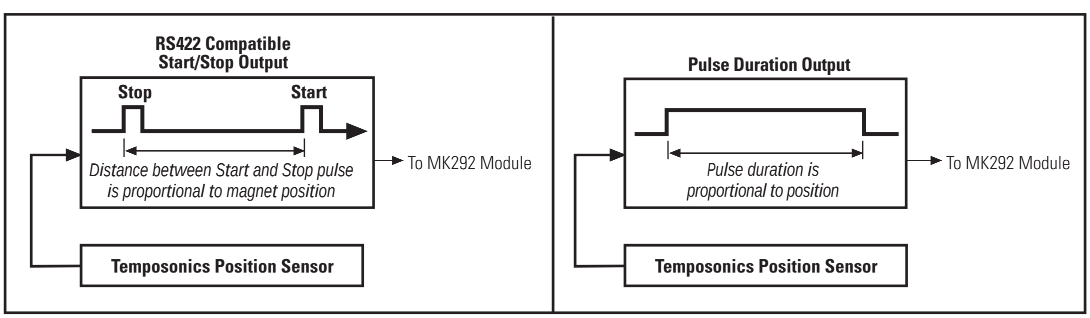


Figure 3-1
Start/stop and PWM Outputs

4. Connections

4.1.1 Temposonics II Position Sensors with DPM or RPM

Table 4-A Connections - Temposonics II Position Sensor

MK292 Connections	Pin No.	Wire Color (Striped Leads)	Wire Color (Solid Leads)	Function w/PWM Output	Function w/Start/Stop Output
C32	1	White/Blue Stripe	White	DC Ground	DC Ground
C32	2	Blue/White Stripe	Brown	Frame	Frame
C28	3	White/Orange Stripe	Gray	(-) Gate Out	(-) Start/Stop Pulse
C27	4	Orange/White Stripe	Pink	(+) Gate Out	(+) Start/Stop Pulse
C30	5	White/Green Stripe	Red	+ 15 Vdc	+ 15 Vdc
C31	6	Green/White Stripe	Blue	- 15 Vdc	- 15 Vdc
No Connection	7	White/Brown Stripe	Black	Not Used	Not Used
No Connection	8	Brown/White Stripe	Violet	Not Used	Not Used
C24	9	White/Gray Stripe	Yellow	(+) Interrogation	(+) Interrogation
C25	10	Gray/White Stripe	Green	(-) Interrogation	(-) Interrogation

NOTE: *Verify if the cable has striped or solid color leads and make connections accordingly.*

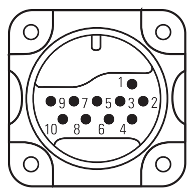


Figure 4-1
10 Pin 'RB' Style Connector
(Mating Connector: P/N 400755-3)

4.1.2 SE-based Temposonics LP Position Sensors with Start/Stop Output

Table 4-B Connections - SE-based Temposonics LP Position Sensor

MK292 Connections	Sensor Pin No.	Wire Color	Function
C28	1	Blue	Gate (-)
C27	2	Green	Gate (+)
C25	3	Yellow	Interrogation (-)
C24	4	Orange	Interrogation (+)
C30	5	Red	Power, provided by MK292 (+15, ± 10%)
C32	6	Black	Ground
No Connection	7	Drain	Shield Drain Wire
No Connection	8	N/A	N/A

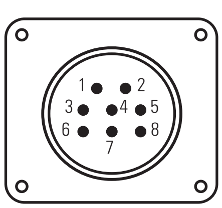


Figure 4-2a
Integral Connector
Connection Type C,
External View

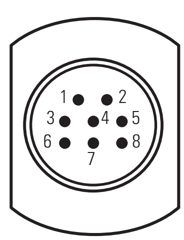


Figure 4-2b
Hanging Connector
Connection Type H or J,
External View

4.1.3 Temposonics L Series Position Sensors with Start/Stop Output

CAUTION!
When wiring Temposonics L Series sensors, DO NOT connect DC ground to the cable shield or drain wire.

Table 4-C.1 Connections - Temposonics L Series Position Sensor with RG Connector

MK292 Connection	*Pin No.*	*Wire Color*	*Function*
C28	1	Gray	(-) Gate
C27	2	Pink	(+) Gate
C24	3	Yellow	(+) Interrogation
C25	4	Green	(-) Interrogation
C2	5	Red or Brown	Power supplied by MK292 (+ 24 Vdc)
C32	6	White	DC Ground
	7	-	No Connection

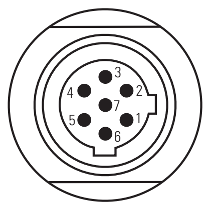


Figure 4-3
RG Connector

Table 4-C.2 Connections - Temposonics L Series Position Sensor with MS Connector

MK292 Connection	*Pin No.*	*Wire Color*	*Function*
C32	A	White	DC Ground
	B	-	No Connection
C28	C	Gray	(-) Gate
C27	D	Pink	(+) Gate
C2	E	Red	Power supplied by MK292 (+ 24 Vdc)
	F	-	No Connection
	G	-	No Connection
	H	-	No Connection
C24	J	Yellow	(+) Interrogation
C25	K	Green	(-) Interrogation

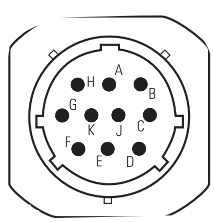


Figure 4-4
MS Connector
(Mating Connector: P/N 370013)

Table 4-C.3 Connections - Temposonics L Series Position Sensor with RB Connector

MK292 Connection	*Pin No.*	*Wire Color*	*Function*
C32	1	White	DC Ground
	2	-	No Connection
C28	3	Gray	(-) Gate
C27	4	Pink	(+) Gate
C2	5	Red	Power supplied by MK292 (+ 24 Vdc)
	6	-	No Connection
	7	-	No Connection
	8	-	No Connection
C24	9	Yellow	(+) Interrogation
C25	10	Green	(-) Interrogation

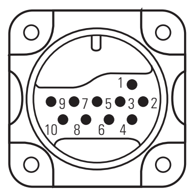


Figure 4-5
RB Connector
(Mating Connector: P/N 400755-3)

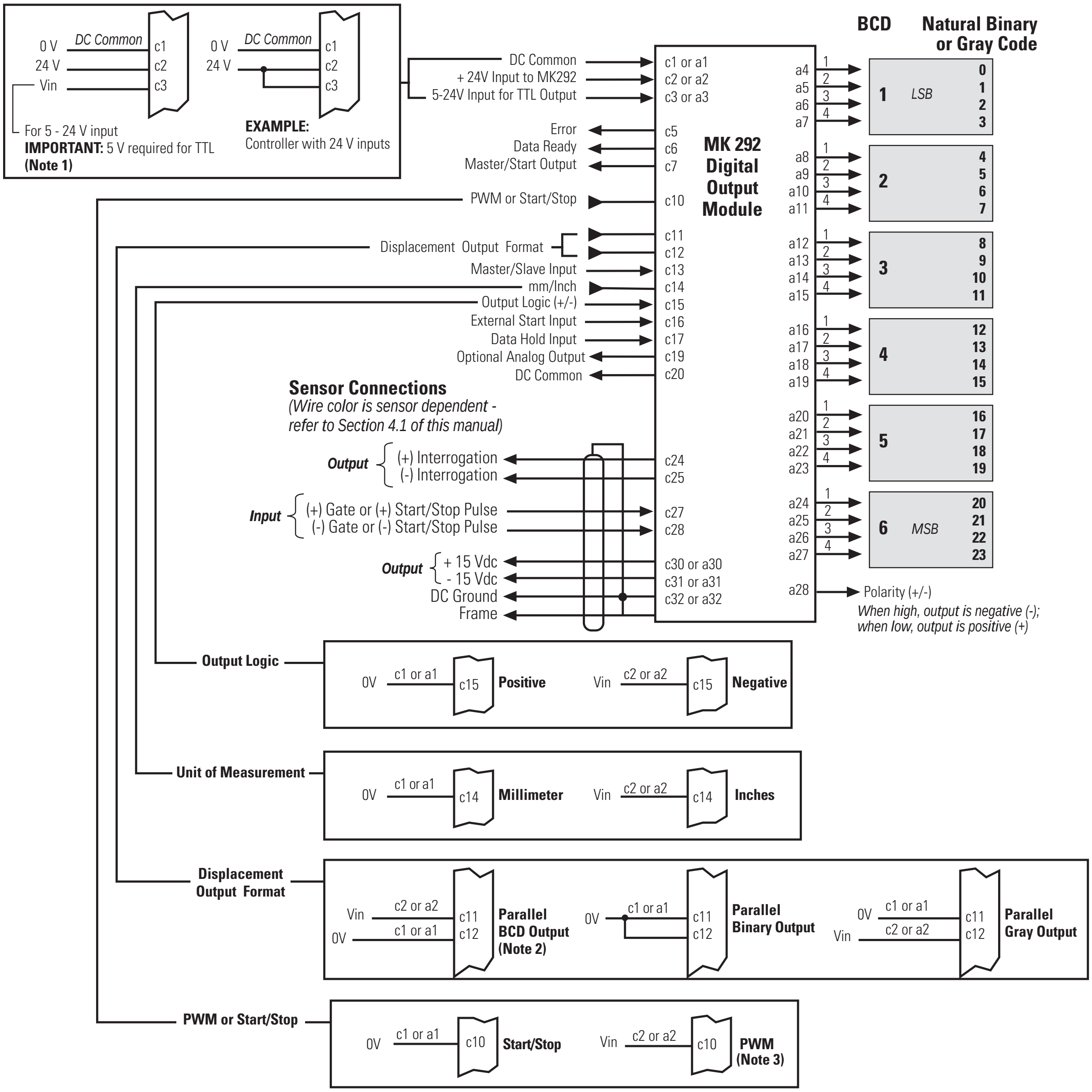
Table 4-C.4 Connections - Temposonics L Series Position Sensor with RO Integral Cable

MK292 Connection	*Wire Color*	*Function*
C28	Gray	(-) Gate
C27	Pink	(+) Gate
C24	Yellow	(+) Interrogation
C25	Green	(-) Interrogation
C2	Red or Brown	Power supplied by MK292 (+ 24 Vdc)
C32	White	DC Ground

Table 4-C.5 Connections - Temposonics L Series Position Sensor with HO Integral Cable*

MK292 Connection	*Wire Color*	*Function*
C28	White	(-) Gate
C27	Black twisted w/white	(+) Gate
C24	Blue	(+) Interrogation
C25	Black twisted w/blue	(-) Interrogation
C2	Red	Power supplied by MK292 (+ 24 Vdc)
C32	Black twisted w/red	DC Ground

**The HO Integral Cable [maximum length 30 feet (9.14 m)] was not available at the time this manual was printed. Please contact the factory for status.*



NOTES:

1. Logic inputs and outputs are relative to voltage level connected to Vin (Pin c3). For example, set Vin to 5 Vdc for TTL, or 24 Vdc for controller with 24 Vdc inputs/outputs.

2. The five digit BCD outputs are limited to stroke lengths 7500 mm when measuring in millimeters. When measuring in inches, BCD output is available for stroke lengths up to 300 inches.

*3. When using a PWM output, the sensors must be configured for **external interrogation**.*

Figure 4-6
System Connections

4.3 Functional Inputs/Outputs

OUTPUTS:
Voltage Level: TTL level to 24 Vdc
Maximum Current Load: 20 mA (high level)

INPUTS:
Control Signal Level: applied Vin level
Current Load per Input: < 1 mA

4.3.1 Error Output (Loss of Feedback)

Pin: c5
Logic: HIGH: No Error; LOW: Error

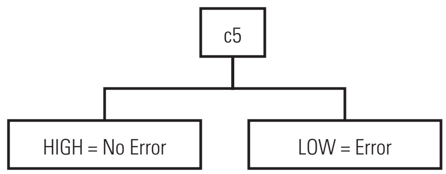


Figure 4-7 Error Outputs

Errors:
- No sensor magnet
- Sensor magnet not positioned within the active range of sensor
- Malfunction or failure of sensor or module
- Electronic interference

4.3.2 Data-Ready Output (Latch Pulse)

Pin: c6
Logic: HIGH

Ensures that parallel data transfer does not occur during data update (i.e., during change in magnet position). In addition, the data ready output confirms that the data is up-to-date.

The timing of data transfer is illustrated below.

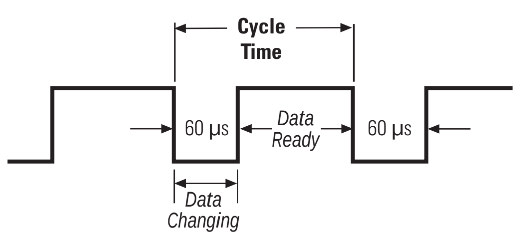


Figure 4-8 Data Ready

4.3.3 Data-Hold Input (Latch Inhibit)

Pin: c17
Logic: HIGH

Data Hold is another means, besides Data Ready, to ensure that parallel data transfer does not occur during data update. When Data Hold (C17) is high, data does not update.

4.3.4 External Start Input (Features)

Pin: c16
Logic: HIGH

The External Start Input permits the timing of the measuring cycle (i.e., the interrogation pulses) to originate from an outside source. The Master/Slave Input (see below) logic must be HIGH before the sensor can be interrogated, normally it is set LOW.

Start signals must be between 6 to 10 microseconds in duration and repetition period must exceed the minimum cycle time -- refer to programming section of the manual: (MR) Measuring Range.

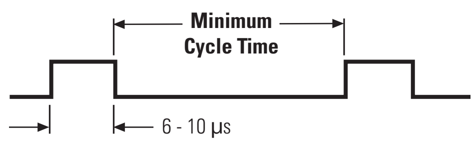


Figure 4-9 External Start

4.3.5 Master/Slave Input (Features)

Pin: c13
Logic: HIGH

If an application requires that more than one Temposonics position sensor provide position data simultaneously, the Master/Slave Input may be used. It is essential to identify the longest position sensor as the master device since it possesses the longest cycle time. The master "start" command is switched to output 'c7' and linked to slave output 'c16' (External Start Input).

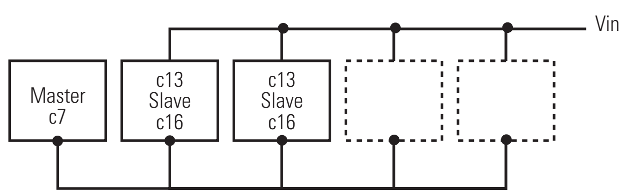


Figure 4-10 Master/Slave

5. System Parameters

After the MK292 Digital Output Module is installed and connected to the Temposonics position sensor, system parameters must be set before start-up. When setting the system parameters, you must be aware which electronics module is installed in the Temposonics position sensor. Verify that the sensor has either a ***start/stop or PWM output***. If the sensor has a PWM output, also verify that it is configured for ***external interrogation***. Contact an MTS Applications Engineer if you have any questions regarding the configuration of your sensor or how to interface to the MK292 unit.

The system parameters for each configuration are indicated below:

SYSTEM PARAMETERS ***(Sensor with PWM Outputs)***				***SYSTEM PARAMETERS*** ***(Sensor with Start/Stop Outputs)***
RUN	<	Programming Mode	<	**RUN**
REC	<	Pulse Duration	<	**N/A**

NOTE: *Pulse Duration (REC) only applies to systems that are using sensors with a PWM output.*

SC	<	Scaling Factor	<	**SC**
RE	<	Resolution	<	**RE**
MR	<	Measuring Range	<	**MR**
ZERO	<	Null Adjustment	<	**ZERO**

System parameters are set via the front panel of the MK292 using the programming and BCD switches.

- **Programming Switch**

This momentary toggle switch is located at the bottom of the front panel. It has two activation positions: #1 and #2. Programming Modes are accessed by manipulation of this switch as defined in the Programming section of this manual.

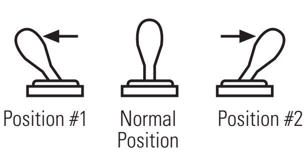


Figure 5-1
Programming Switch Positions

When the Programming Switch is pushed into either Position #1 or Position #2 it will automatically return to the center (normal) position when released.

• BCD Switches (S1-S6)

The six rotary switches, S1 (least significant digit) to S6 (most significant digit), are used to set parameter values. A screw driver or adjusting tool is used to set the switches.

The input values are checked against the actual values as indicated by the customer provided controller display.

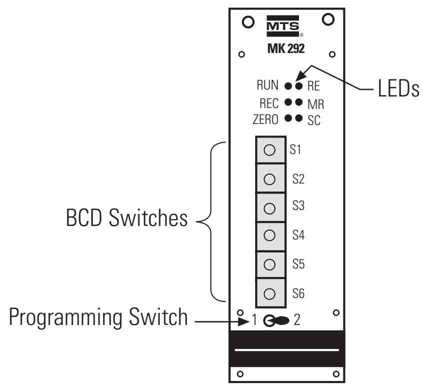


Figure 5-2
Front Panel of MK292 Module

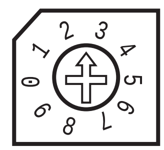


Figure 5-3
BCD Switch

• LEDs

There are six LEDs, one red and five green, which give visual indication of the operating condition and programming mode of the MK292.

1. RED (continuous light) = System in operation mode
2. RED (flashing light) = Transition to programming mode
3. GREEN (continuous light) = Indication of selected parameter
4. GREEN (flashing light) = Programming mode is activated – parameter settings can be changed via BCD switches S1-S6.
5. GREEN (fast flashing light) = Input error

6. Short Form Programming Procedure

- **Programming Mode**

  Hold the programming switch in ***Position #1*** (see Fig. 6.1) until the ***'RUN'*** LED begins to flash (3 sec.) Programming Mode is set up.

- **Selection of System Parameters**

  To select desired parameter, momentarily toggle the programming switch to ***Position #1*** and release; an LED will light. Repeat until the LED is lit next to desired parameter.

> **NOTE:**
> *You may cycle through and check the parameters by observing the controller display as you repeatedly put the programming switch in Position #1.*
>
> *To change a parameter: Select desired parameter, then simply hold the programming switch in Position #2 until the LED flashes (3 sec.). Change parameter using the BCD switches.*

- **Parameter Adjustment**

  Enter desired values using BCD switches S1-S6 (S1 represents the least significant digit). Rapid flashing of the green LED indicates input error.

- **Parameter Setup**

  To store a newly set parameter, hold the programming switch in ***Position #2*** (see Fig. 6.1) until the LED of the next parameter is activated (3 sec.)

> **NOTE:**
> *If the value cannot be stored, momentarily hold the programming switch in Position #1, and repeat, until you cycle through to the desired parameter.*

- **Operation Mode**

  Hold the programming switch in ***Position #1*** until the red ***"RUN"*** LED is activated. This indicates that the Programming Mode has been exited and the Operation Mode is ready.

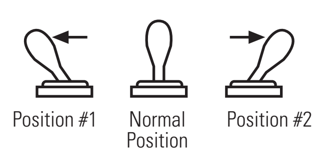


Figure 6-1
Programming Switch Positions

For detailed instructions on programming the MK292 Digital Output Module, refer to Section 7 of this manual.

7. Detailed Programming Procedure

7.1 (RUN) Programming Mode / Red LED

During initial start-up, the red 'RUN' LED will flash. This indicates that the MK292 is in the programming mode and input parameters are required for operation.

If the 'RUN' LED is on, but not flashing, this means that parameters have already been set. If parameters must be changed, the programming mode must be accessed, as follows:

RUN
ADJUST — Hold programming switch in Position #1 until 'RUN' LED flashes (3 sec.)

7.2 (REC) Pulse Duration / Green LED

> **NOTE:**
> *This parameter only applies to systems that have a Temposonics position sensor with a PWM output. In the procedure, this step will not occur if the MK292 is configured for a start/stop output.*

Temposonics sensors with a PWM output are capable of “circulations”, meaning that the interrogation and return signals can be recirculated a specific number of times. This lengthens the duration of the PWM output from the sensor and the counting time of the MK292; the result is increased resolution.

The number of circulations is determined at the time of order and is reflected in the sensor’s model number. Refer to the appropriate ordering guide for the sensor that you are using to determine the circulation count. If you have any questions regarding this, contact an MTS Applications Engineer.

REC 1) Hold the programming switch in Position #2 until the 'REC' LED is flashing (3 sec.)
ADJUST 2) Enter the Pulse Duration (recirculation value) using BCD switches S1-S6.

Example:

> **NOTE:**
> *The chart below defines the MK292-programmable resolutions. It is important to note that with resolution finer than 0.0002 in., instabilities will be detected on the Least Significant Bits.*

Resolution vs. Circulations

Maximum	*Minimum*	*Circulation Count*
See note above	0.00025	16
0.00025	0.0005	8
0.0005	0.001	4
0.001	0.002	2
0.002	0.004	1

Maximum Resolution Formulas:

- Resolution in millimeters = (0.0508 ÷ Circulation Count)
- Resolution in inches = (0.002 ÷ Circulation Count)

Switch Setting: PWM Output (circulations)

BCD Switch	*Circulations: 4*	*Circulations: 16*
S1	4	6
S2	0	1
S3	0	0
S4	0	0
S5	0	0
S6	0	0

REC 1) Hold the programming switch in Position #2 until the 'SC' LED is flashing (3 sec.)
ADJUST

The MK292 is now ready to accept the next parameter – Scale Factor (SC).

7.3 (SC) Scaling Factor / Green LED

Each Temposonics position sensor has its own specific scale factor (gradient) which describes the velocity of the torsional strain pulse through the waveguide medium (refer to 'Principle of Operation'). The gradient is indicated on the sensor's label. Upon initial start-up or when replacing sensors, this value must be set to recalibrate system.

I M P O R T A N T

Scale Factor or Gradient

For stroke lengths defined in inches (Pin c14 set for inches), the scale factor or gradient is described in microseconds per inch. This value is indicated on the sensor's label (see Fig. 7.3).

For stroke lengths defined in millimeters (Pin c14 set for millimeters), the scale factor or gradient is described in meters per second.

The formula to convert µs/in, to m/s is as follows:

(Scale in m/s) = 25,400 ÷ (Scale in µs.in.)

Example:
Scale (Gradient) = 8.94371 µs/in.

25,400 ÷ 8.94371 µs/in = 2839.98 meters/second

SC
ADJUST

1) Momentarily tap the programming switch to Position #1, the 'SC' LED will light.
2) Hold the programming switch in Position #2 until the 'SC' LED begins to flash (3 sec.)
3) Enter the scale factor indicated on the sensor label using the BCD switches (S1 - S6).

Example: Gradient = 8.94371

BCD Switch #	*Settings*
S1	1
S2	7
S3	3
S4	4
S5	9
S6	8

SC
SETUP — Hold the programming switch in Position #2 until the 'RE' LED is lighted (3 sec.)

The MK292 is now ready to accept the next parameter – Resolution (RE).

7.4 (RE) Resolution / Green LED

The resolution that can be achieved by the MK292 is dependent on the input from the Temposonics position sensor. The chart below indicates the range of resolutions depending on sensor type. Note that sensors with PWM output must be set for the appropriate number of circulations to achieve desired output resolution.

RESOLUTION
Start/Stop Output
Range: 0.1 in. to 0.002 in. or 2.54 mm to 0.05 mm

PWM Output
Range: 0.1 in. to 0.0002 in. or 2.54 mm to 0.005 mm
(Note: Refer to Resolution vs. Circulation Chart, page 16)

RE
ADJUST
1) Hold the programming switch in Position #2 until the 'RE' LED begins to flash (3 sec.)
2) Enter the desired resolution using BCD switches S1 - S6.

Table 7A

SWITCH SETTINGS / RESOLUTION IN INCHES						
Switches	***0.0002 in.***	***0.0004 in.***	***0.002 in.***	***0.004 in.***	***0.02 in.***	***0.039 in.***
S1 (0.000X)	2	4	0	0	0	0
S2 (0.00X)	0	0	2	4	0	9
S3 (0.0X)	0	0	0	0	2	3
S4 (0.X)	0	0	0	0	0	0
S5	0	0	0	0	0	0
S6	0	0	0	0	0	0

Table 7B

SWITCH SETTINGS / RESOLUTION IN MILLIMETERS						
Switches	***0.005 mm***	***0.01 mm***	***0.05 mm***	***0.1 mm***	***0.5 mm***	***1.0 mm***
S1 (0.000X)	0	0	0	0	0	0
S2 (0.00X)	5	0	0	0	0	0
S3 (0.0X)	0	1	5	0	0	0
S4 (0.X)	0	0	0	1	5	0
S5	0	0	0	0	0	1
S6	0	0	0	0	0	0

RE
SETUP — Hold the programming switch in Position #2 until the 'MR' LED begins to flash (3 sec.)

The MK292 is now ready to accept the next parameter – Measuring Range (MR)

7.5 (MR) Measuring Range / Green LED

The measuring range or "stroke length" of the sensor must be set accurately to optimize the interdependence of the other parameters. This value is indicated on the sensor label as "stroke" and will be in either inches or millimeters.

> **NOTE:**
> *Pin c14 of the MK292 permits you to select the unit of measurement (i.e., inches or millimeters) and must be wired accordingly (refer to section 4.2).*

MR
ADJUST

1) Hold the programming switch in Position #2 until the 'MR' LED begins to flash (3 sec.)
2) Enter the measuring range using BCD switches S1 - S6.

Example:

INCHES
Measuring Range: 120.5 inches

Switch (in.)	*Setting*
S1 (0.1)	5
S2 (1.0)	0
S3 (10)	2
S4 (100)	1
S5 (n/a)	0
S6 (n/a)	0

MILLIMETERS
Measuring Range: 1525 millimeters

Switch (mm)	*Setting*
S1 (1.0)	5
S2 (10)	2
S3 (100)	5
S4 (1000)	1
S5 (n/a)	0
S6 (n/a)	0

> **NOTE:**
> *When the measuring range is set, the measuring frequency and system update time is also set. Refer to the tables below to see the relationship of measuring range, frequency, and update time.*

Update Time Formula:

Tud = [(Lm + 120 mm) (13) (N)] ÷ 36

Where:
Update Time (in milliseconds) = Tud
Length in mm = Lm
Circulation Count = N

> **NOTE:**
> *When using inches, use the following formula to convert inches to millimeters:*
> *Inches x 25.4*

MR
SETUP

1) Hold the programming switch in Position #2 until the 'ZERO' LED begins to flash (3 sec.)

The MK292 is now ready to accept the next parameter -- Null Adjust (ZERO).

7.6 (ZERO) Null Adjust / Green LED

Null adjust allows you to set the mechanical ZERO position anywhere within the active measuring range of the position sensor. Move the sensor magnet to the desired ZERO position and proceed as follows:

ZERO
ADJUST

1) Hold the programming switch in Position #2 until the 'ZERO' LED begins to flash (3 sec.)

The displacement output indicates position without the offset calculation

2) Set switches S1-S6 to ZERO position.

ZERO
SET UP

1) Hold the programming switch in Position #2 to restart programming sequence. (3 sec.)

> **NOTE:**
> *If a set value is overwritten, the programming mode has to be set again by repeatedly tapping the dip switch to position #1.*

7.7 (ZERO) Offset

As an alternative to the ZERO/NULL adjust, a ZERO/NULL offset can be programmed within a range of -49.9999 to +49.9999 inches. The value depends on the pre-set resolution of the position sensor. The offset is set by using S6 only.

Positive Offset	*Negative Offset*
0 = +0	5 = -0
1 = +1	6 = -1
2 = +2	7 = -2
3 = +3	8 = -3
4 = +4	9 = -4

Forward Acting - Positive offset counts down when magnet is moved to the head and counts up when moved to the tip.

Reverse Acting - Negative offset counts up when magnet is moved to the head and counts down when moved to the tip.

Move the magnet to the desired mechanical start position and calibrate the offset as follows:

OFFSET ADJUST

1) Hold the programming switch in Position #2 until the 'ZERO' LED begins to flash (3 sec.)

The displacement output indicated position without the offset calculation

2) Enter the desired offset value using BCD switches S1-S6.

EXAMPLE: Switch Settings S1-S6 for Offset Value

POSITIVE OFFSET (in inches)

BCD Switch	*+00.3571*	*+04.5841*	*+03.5705*	*+45.8405*
S1	1	1	5	5
S2	7	4	0	0
S3	5	8	7	4
S4	3	5	5	8
S5	0	4	3	5
S6	0	0	0	4

NEGATIVE OFFSET (in inches)

BCD Switch	*-00.3571*	*-04.5841*	*-03.5705*	*-45.8405*
S1	1	1	5	5
S2	7	4	0	0
S3	5	8	7	4
S4	3	5	5	8
S5	0	4	3	5
S6	5	5	5	9

OFFSET SET UP

1) Hold the programming switch in Position #2 to restart programming sequence. (3 sec.)

NOTE:

If a set value is overwritten, the programming mode has to be set again by repeatedly tapping the dip switch to Position #1.

7.8 (RUN) Operation Mode / Red LED

RUN
SETUP

1) Hold the programming switch in Position #1 until the 'RUN' LED begins to flash (3 sec.)

The Programming Mode is exited and all parameter settings are stored in an EEPROM within the MK292 module. You are now in Operation Mode.

8. Optional Analog Output for the MK292 (for Recording Purposes Only)

NOTE:
The analog output is available as an option and must be specified at the time of order. An additional analog sub-print is required.

The analog output option functions in two operational modes:
1. Normal (NORM)
2. Programmable Adjustment (PROG)

WARNING!
When powering down during analog operation, switch must remain in programming mode or all parameters will be lost.

Operation mode is selected with the switch on the analog sub-print board (see Fig. 8.1).

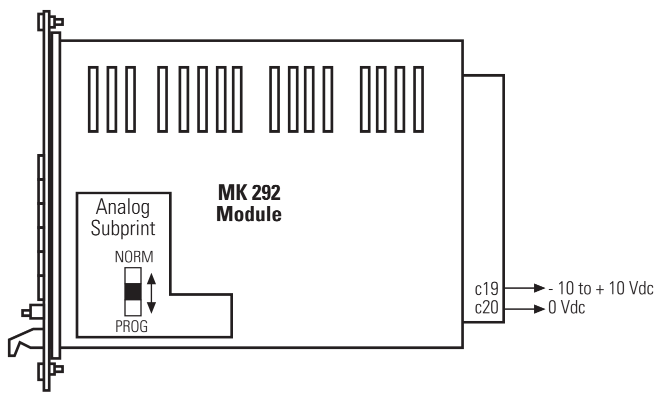


Figure 8-1

8.1 Operation Mode 1 (Normal)

Analog Sub-print Switch (S1) = NORM

The analog output configuration is defined by the zero position and measuring range of the sensor. The three possible configurations are illustrated in Fig. 8.2.

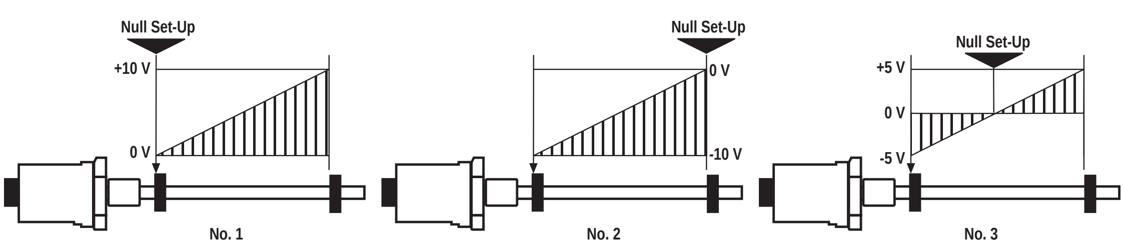


Figure 8-2

If the magnet leaves the defined measuring range of the sensor, the system will indicate the following outputs:

1. If the magnet leaves the measuring range moving towards the end of the sensor rod, the output voltage will be NEGATIVE.
2. If the magnet leaves the measuring range moving toward the electronics head of the sensor, the output will be a constant +10V.

8.2 Operation Mode 2 (Programmable Adjustment)

The analog output configuration can be set-up by defining the desired output range of the sensor with two set-points (SP1 and SP2).

> **IMPORTANT NOTES:**
> - *SP1 and SP2 must be within the valid measuring range*
> - *SP1 must be located nearer the sensor head than SP2*
> - *SP1 and SP2 can have output values between -10 V and +10 V*

Switch S1 = ON (PROG)

SP1 Programming:

1.) Move the magnet to the desired SP1 position.

2.) Hold the programming switch in Position #1 until the **RUN** LED begins to flash (3 seconds) Programming Mode is set up.

3.) Momentarily toggle the programming switch to Position #1 and release and repeat until **ZERO + SC** become lit.

4.) Hold the programming switch in Position #2 until **SC** begins to flash (3 seconds). **ZERO** is also lit.

5.) Enter the desired analog out at SP1 using the BCD switches (S1 = least significant bit, S5 = most significant bit).

6.) Hold the programming switch in Position #2 until **SC** is lit (3 seconds). **ZERO** is also lit.

7.) The output value at SP1 is now stored.

> **NOTE:**
> *Setting up a value outside the valid voltage range will be detected and SC will flash rapidly to indicate an error.*

SP2 Programming:

1.) Move the magnet to the desired SP2 position

2.) Hold the programming switch in Position #1 until the **RE** LED begins to flash (3 seconds). **ZERO** is also lit.

3.) Enter the desired analog out at SP2 using the BCD switches (S1 = least significant bit, S5 = most significant bit).

4.) Hold the programming switch in Position #2 until **SC** is lit (3 seconds). **ZERO will no longer be lit**.

5.) Hold the programming switch in Position #1 until the **RUN** LED is lit (3 seconds). The output value at SP2 is now stored and the system has entered the Operations Mode.

> **NOTE:**
> *Setting up a value outside the valid voltage range will be detected and RE will flash rapidly to indicate an error.*

EXAMPLE, BCD Switch Settings

SP1 = + 7.565 V	*SP2 = - 9.480 V*
S1 = 5	S1 = 0
S2 = 6	S2 = 8
S3 = 5	S3 = 4
S4 = 7	S4 = 9
S5 = 0	S5 = 0
S6 = 0	S6 = 9

NOTE:

To configure a negative setpoint value: S6   5.

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MTS®

TEMPOSONICS®
Position Sensors

550912A

User's Manual

Analog Position Sensor System with Separate Electronic Interface
1. Position Sensor Temposonics-II
2. Analog Board AK 288

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1. Introduction

The absolute and linear TEMPOSONICS Position Sensing system is an analog measuring device with highest resolution. Consisting of a sensor TEMPOSONICS-II with built-in R-Module in the sensor head and the separate evaluation interface AK 288.
The TEMPOSONICS system measures the time interval between a Start and a Stop signal. In the sensor, a torsional strain pulse is induced in a specially designed magnetostrictive waveguide by the interaction of two magnetic fields under the positioning head.
The running time, proportional to the displacement will be converted into an analog voltage or current output (Fig 1).

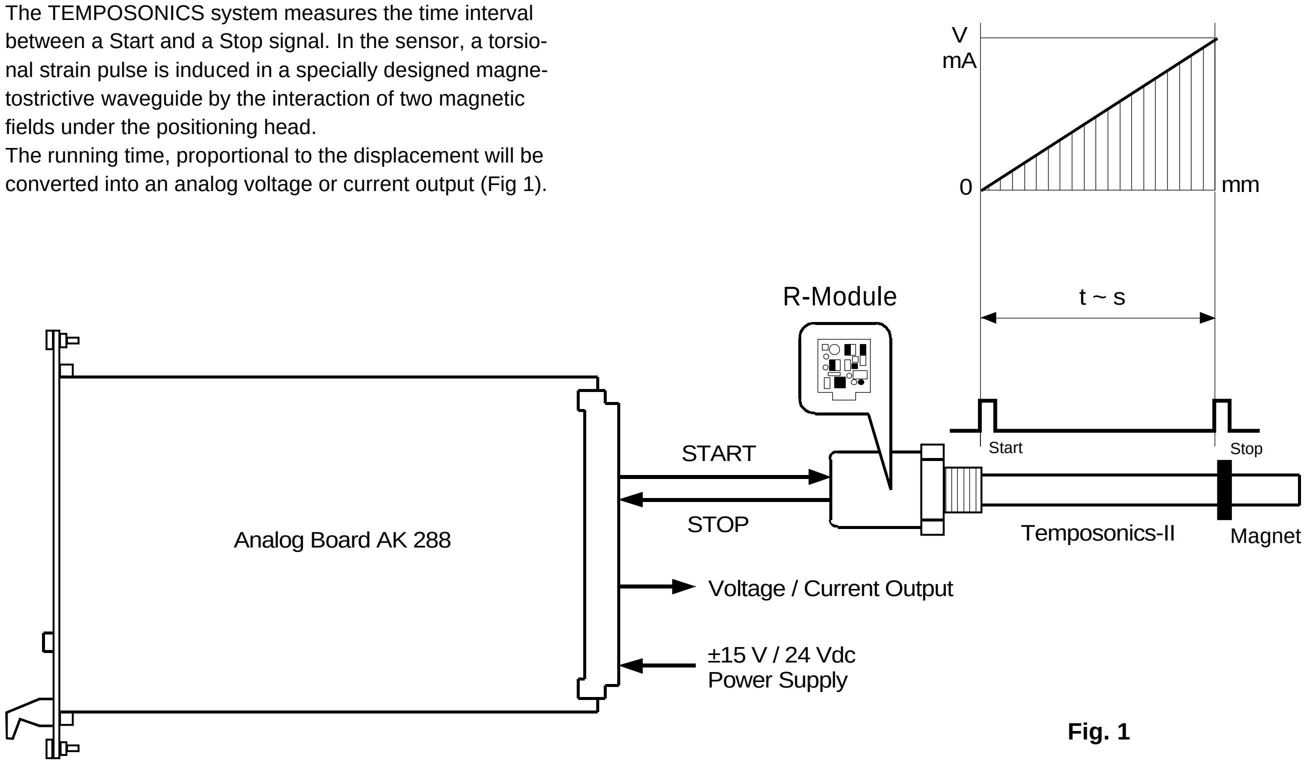


Fig. 1

2. Analog Board AK 288

2.1 Design and Operations

The AK 288 card in Europe format 100 x 160 mm is suitable for installation in a 19" sub-rack, for 32-pin insert card blocks of structural shape C (DIN 41612) or Snap-in card housing.
The board consists of the following function units:

1. **Control Logic and Start/Stop-pulse processing**
2. **Measuring Length Calibration**
3. **Noise Rejection**
4. **Analog Output with**
   - Reference Voltage
   - Analog Switch
   - Filter and Amplifier for Null and Span
5. **Error Output**

The card generates the measuring repeat frequency and generates a pulse width from the start/stop signal which is proportional to the position of the magnet head. The pulse duration controls a precision analog switch used to switch an internal reference voltage to an active filter. The filter forms an analog voltage from the gate which is directly proportional to the magnet position.

The Error Output of board AK 288 shows " Low " level, if

- the magnet on the sensor is missing
- no sensor is connected
- the power supply of sensor is missing
- the board is defective
- the Error-Input Pin a16 is not connected

The Error Output requires an additional power supply of +15V or +24Vdc on Pin a16. Pin c16 shows that voltage output if the board AK 288 has no fault.

2.2 Block Diagram AK 288

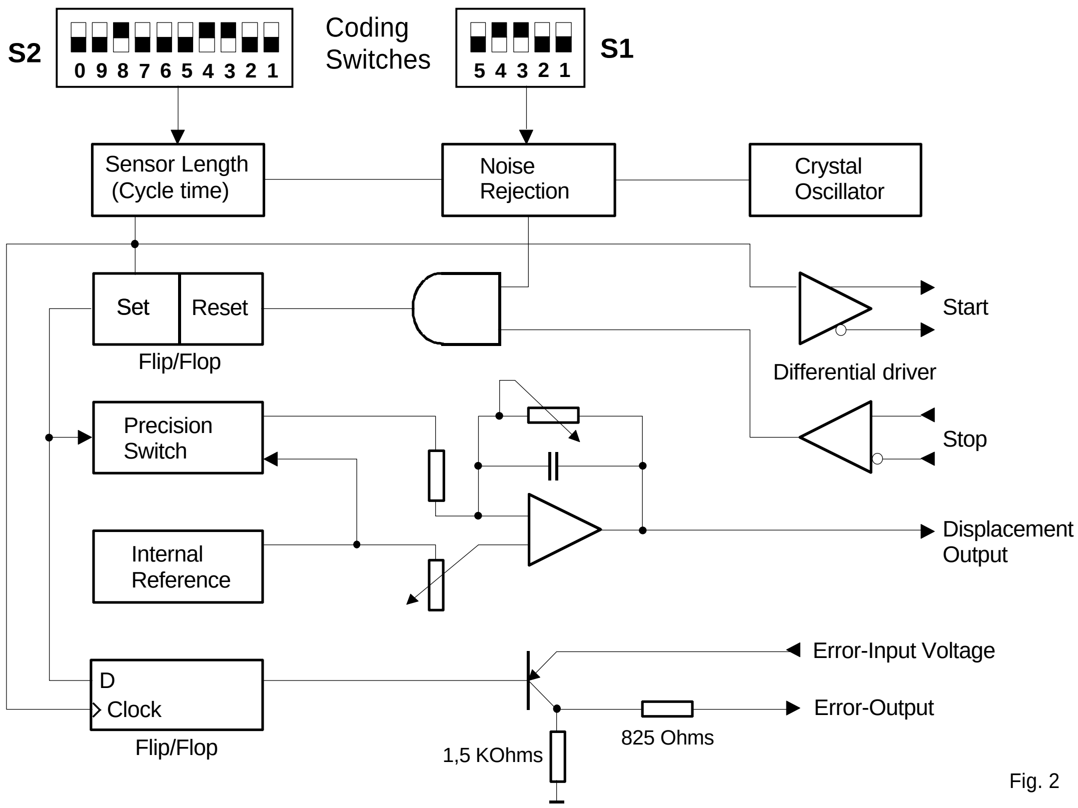


Fig. 2

3. Installation

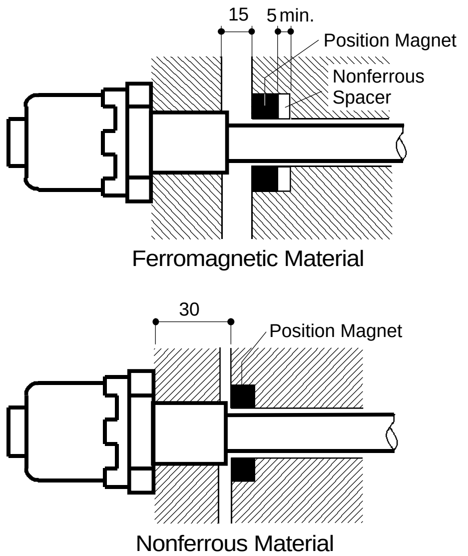
Measuring and control technology as a component of modern production facilities are often surrounded by interference factors which can impair the function of the electronic system. For this reason the measuring technology should be installed very carefully and attention paid to the following items (see fig 3.)

3.1 Installing the Sensor

The sensor has to be mounted to the machine in any position. The measuring point is definated by the position magnet that has to be connected to the moving machine part and it slides over the transducer rod without wearing.

For mechanical installation see the below figures illustrating minimum clearances of transducer magnets and note following items for the very best function of the device.

- Use non-ferrous material (screws, supports etc.)
- Using ferromagnetic materials, the magnet needs spaces between the surface of the magnet and material
- Long Sensors (above 1000 mm measuring stroke) may require mechanical supports



Mounting examples:

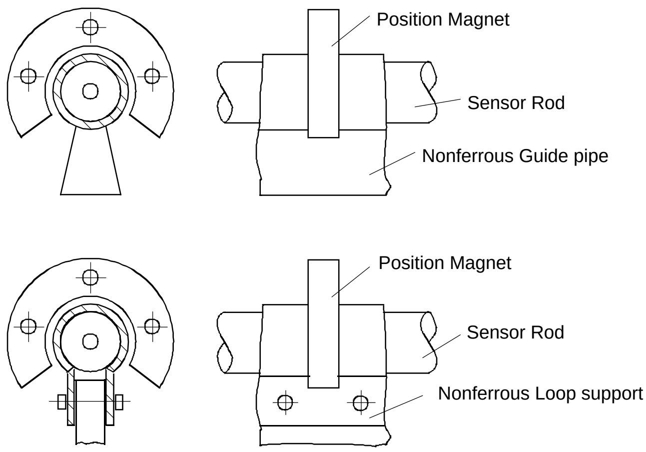


Fig. 3

3.2 Installing the Board

The analog displacement board AK 288 has the European standard format 100 x 160 mm for mounting in 19"-racks. For mounting in control cabinets it is also possible to use standard card holders, form C, 32 pins, a + c row. Over the terminal block the sensor interface can be wired directly to the sensor.

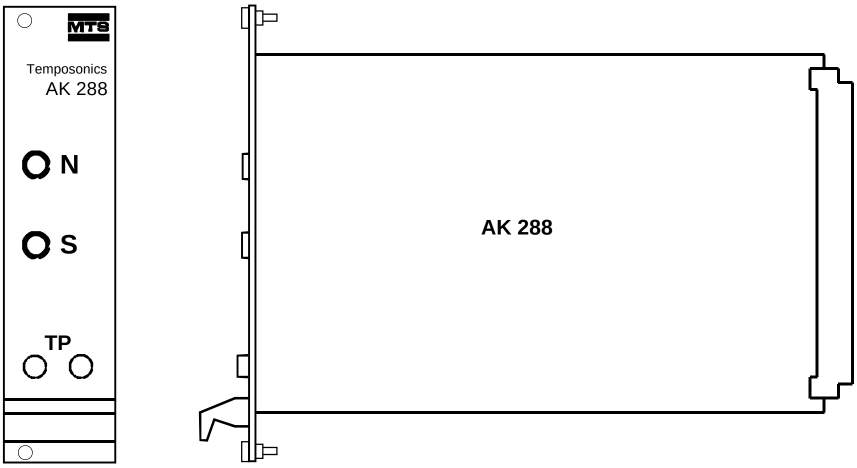


Fig. 4

3.3 Cable

Electrical faults are often caused by the long data lines with defective and incorrect cable laying. The Start/Stop pulse is transmitted as a differential signal.
Cable connection between sensor and card of 500 meters are possible.

Attention! All connections are measuring cable and must be treated as such.

- Do not lay cable near and parallel to sources of interference such as engine lines, frequency converters, valve lines or other lines with high switching inductivity
- Lay low-impedance cable
- Avoid earth circuits
- Use twisted cable with a shield
- The shielding of the sensor feed should be matched to the overall concept of the control.

Possible shields are

- One-sided sheath to machine ground (standard)
- One-sided sheath to 0 volts
- Two-sided sheath to machine ground
- External sheath to machine ground. Internal shield to 0 V power supply (applies only to double shielded cable of type LiYCY-CY....)
- We recommended following cable type:
  8 x 0,25 mm² / twisted pairs / shielded
  e.g. LiYCY 4 x 2 x 0,25 mm² or
  LiYCY-CY 4 x 2 x 0,25 mm²

3.4 Power Supply

Power units can also cause interference to the measuring system. This often happens in facilities on which joint power supplies are used which then transmit interference peaks from other components.
Only stabilized power supplies guarantee trouble-free functioning of the Temposonics measuring device.
Please note the connected loads right.

Attention! Do not connect other voltages. That can damage electronic components of sensor or board.

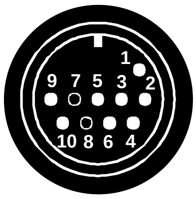
Input: ±15 V dc (± 0,5 V)

- **+15 V** current consumption: 250 mV max.
- Ripple: 200 mV max.
- **-15 V** current consumption: 100 mV max.
- Ripple: 200 mA max.

Input: 24 Vdc (± 1,2V)

- Current consumption: 250 mA max.
- Ripple: 200 mV max.

3.5 Connections of Sensor Temposonics-II



	Connector	Cable color	TEMPOSONICS-II / Series TTA; TTM and TTS
10-pin MTS-Connector type ***RB*** (male) External view	Connector Pin No.	Cable type K 32 4 x 2 pairs	Type TTA/TTM/TTS-*RB*-M-❐❐❐❐-R (Integral connector) Type TTA/TTM/TTS-*R0*-M-❐❐❐❐-R (Integral cable)
			Power Supply
	1	white	DC Ground (0V)
	2	brown	Machine Ground (Frame)
	5	red	+15V
	6	blue	-15V
			Pulse Transmission
	3	gray	Stop (-)
	4	pink	Stop (+)
	7		
	8		
	9	yellow	Start (+)
	10	green	Start (-)

3.6 Wiring Sensor - Analog Board

Following TEMPOSONICS components can be connect to an analog sensor system

Position Sensor

1. Type TTA; TTM and TTS - RB - M - xxxx- R (Connector version)
2. Type TTA; TTM and TTS - R0 - M - xxxx - R (Cable version)

Analog Board

1. Type AK 288 - xx - 0 - xxxx (±15 Vdc Input)
2. Type AK 288 - xx - 1 - xxxx (24 Vdc Input)

Do not carry out any connection with power on !
The Start/Stop pulse transmission between Sensor and Board is a differential signal.
Cable length: Maximum of 500 meters (see page 3)
Cable type: Shielded Cable with twisted pairs
e.g. LiYCY 4 x 2 x 0,25 mm² or
LiYCYCY 4 x 2 x 0,25 mm²

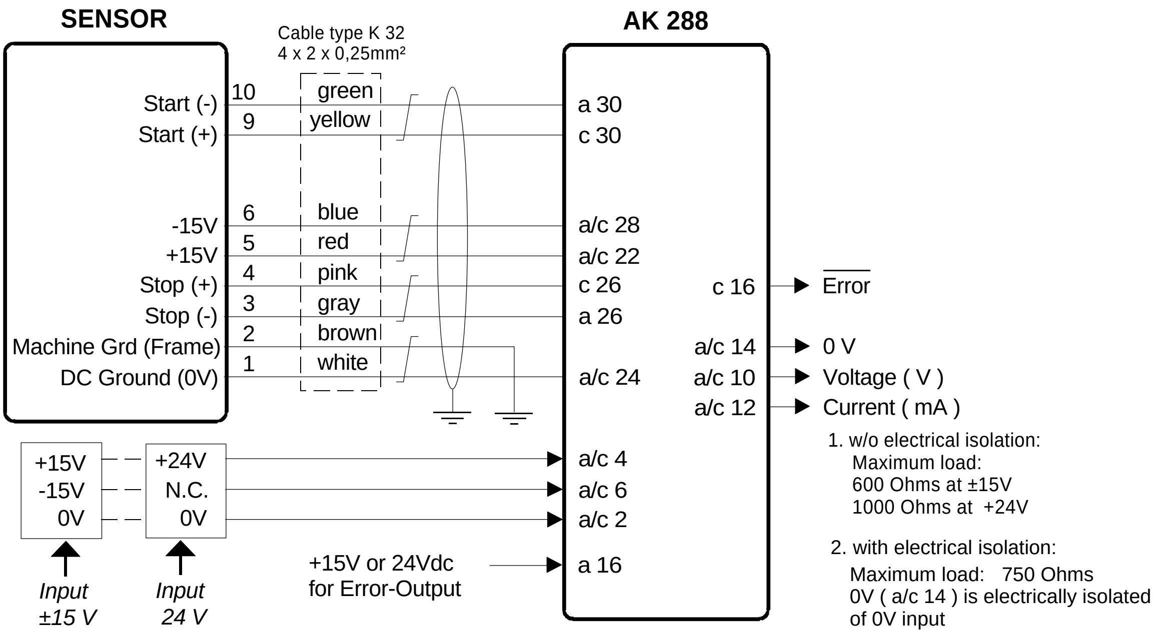
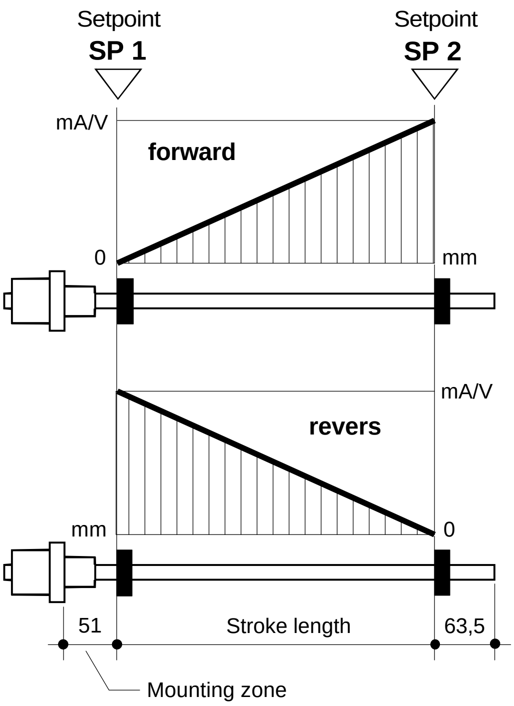


Fig. 5

4. Operational Check

4.1 Adjustment Start-Position and End-Position

Note: All boards are factory-set to the following customized parameters
• Sensor Length
• Noise rejection
• Measuring direction
• Position of Setpoints SP1 and SP2
• Output
A difference is made between standard and customized adjustments.



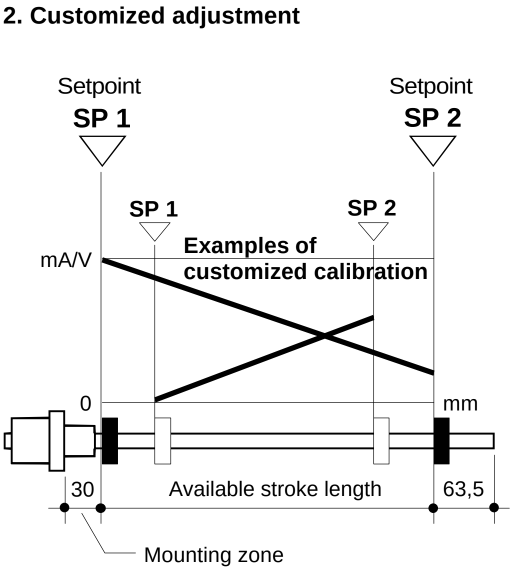


Fig. 6

Small offsets in the magnet position due to mounting or wear in the moving parts of the mechanical system to which the magnet is attached can be compensate by the adjustments of 2 potentiometers in the card front panel:

1. Bring Position magnet to the factory adjusted **ZERO** and **SPAN** position (Setpoints SP1 and SP2) and check the outputs with help of a digital voltmeter or the connected controller.

2. Adjust **START** position (NULL) if necessary by potentiometer **" N "**

3. Adjust **END** position (SPAN) if necessary by the potentiometer **" S "**

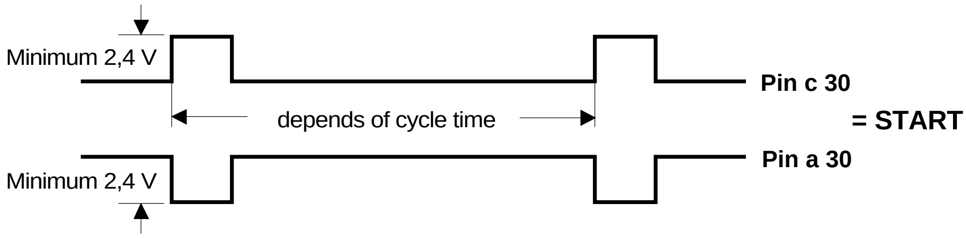
To guarantee the high accuracy of the TEMPOSONICS analog measuring device, that adjustments of 'N' and 'S' are only possible in the small range of ±1% of full stroke.

Important! Independent of measuring direction, valid is:
The **Start Position** will be adjusted always with pot **'N'**
The **End Position** will be adjusted always with pot **'S'**

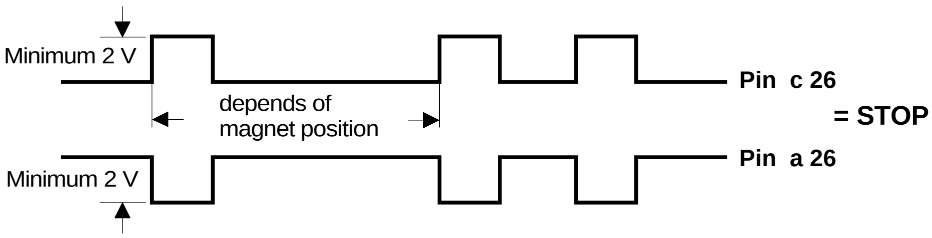
4.2 Troubleshooting

Use the troubleshooting procedure in this section when operational problems are encountered. Note, that the following checks are only for general diagnostic purposes.

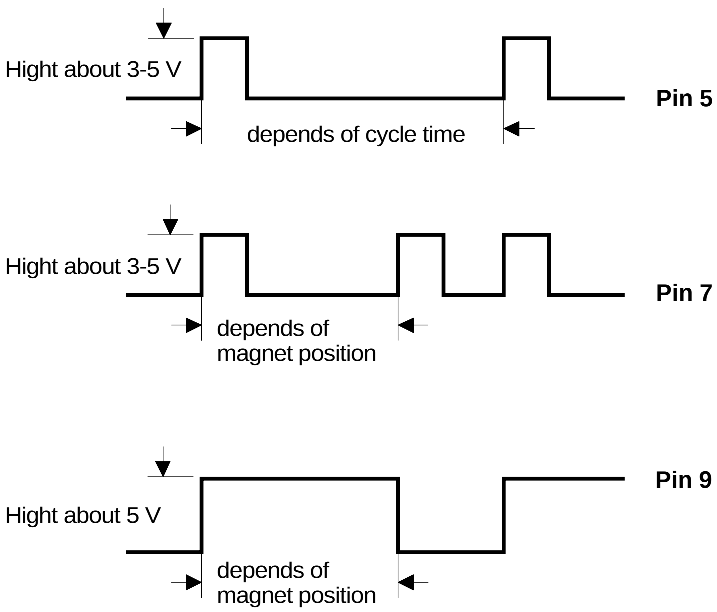
1. Check the cable connections
2. Check the power supply of the board AK 288
3. Check the Power supply board to displacement sensor
4. Check the START - SIGNAL on the multipoint plug of the card with an oscilloscope

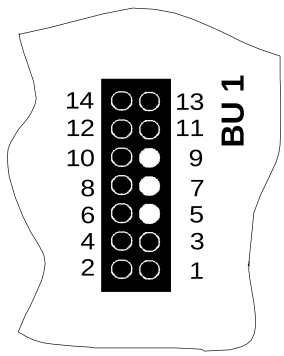


5. Check the STOP - SIGNAL on the card ' s multipoint plug



6. The following signals must be measured at the pins of the test socket **" BU 1 "** (see fig. 7 / page 7)





Test Socket
Component side

7. At the 2 testpoints **" TP "** on the board frontpanel (right) the actual DISPLACEMENT VALUE can be measured as an analog voltage output.

Please use this signal output for testing only !

5. System Calibration

ATTENTION! All Boards are factory adjusted. Following detailed instructions are for scaling to altered local conditions only or for a new setting of a neutral spare part board.

5.1 Sensor Length and Cycle Time
5.2 Noise Rejection
5.3 Measuring Direction
5.4 Output of Start and End Points

are variable parameters. For changements of the factory calibration note the adjustment items on following pages. Position of calibration components you can find on the board component side below.

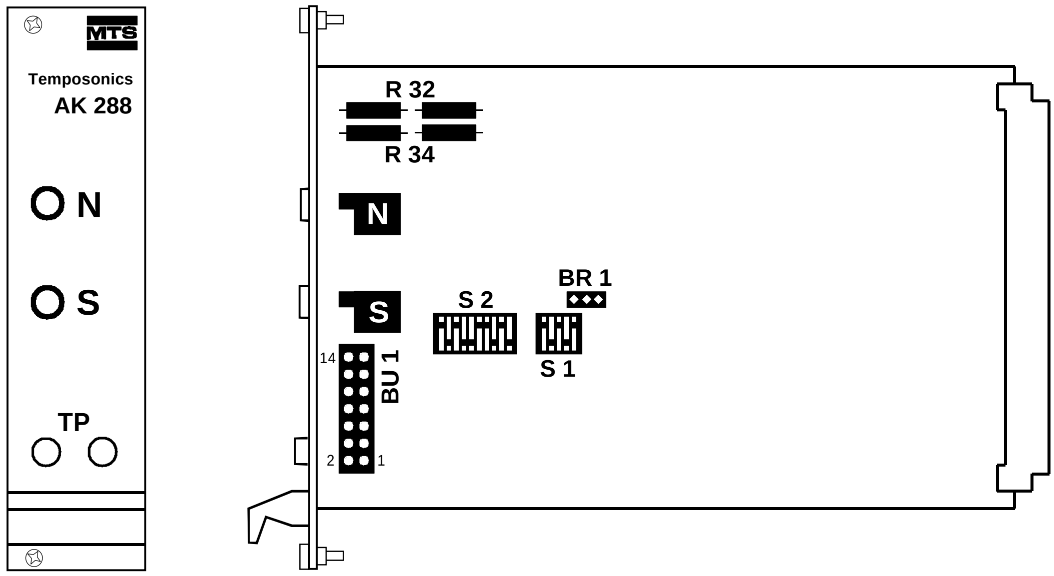
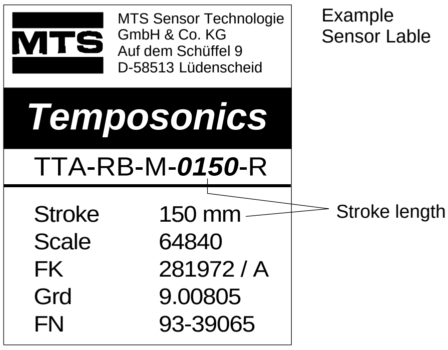


Fig. 7

5.1 Sensor Length and Cycle Time

To optimize the cycle time (measuring frequency), the AK 288 must always be adjusted to the Sensor Length of the connected Temposonics-II transducer.
The Sensor Length is the addition of labled stroke length, mounting zone (51 mm) and a fixed value of 46 mm (see below).



The Sensor Length must be programmed with the dip switches No. 0-9 of the code switch S2 (fig.8) in On/Off position.

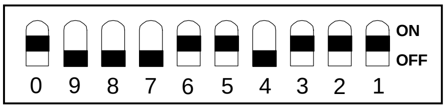


Fig. 8 - Code switch S2

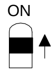
5.1.1 Calculation of Total Value (GW):

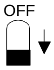
$$GW = \frac{\text{Stroke length + 51mm Mounting zone + 46 mm}}{\text{17,9 mm}}$$

Always round up the calculated value !

5.1.2 Setup Code switch S 2

- Each of the dip-switches 0 - 9 of code switch S2 has a Single Value (EW) as shown in table 1.
- EW (Single Value) which is closest to the calculated GW (Total Value) read from the table 1 and add EW`s until GW is reached.
- Set the slide switches 0 - 9, with the single value (EW) to position ON.

ON


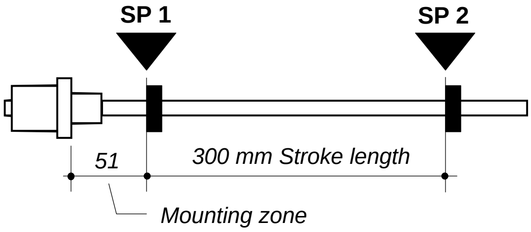
OFF


- All other switches must be in position OFF.

Single Value (EW)	Dip Switch	Cycle Time (µsec)	Sensor Length (mm)
1	0	6.4	17.9
2	9	12.8	35.8
4	8	25.6	71.6
8	7	51.2	143.2
16	6	102.4	286.4
32	5	204.8	572.8
64	4	409.6	115.6
128	3	819.2	2291.2
256	2	1638.4	4582.4
512	1	3264.8	9164.8

Table 1

Example of Scaling Sensor Length

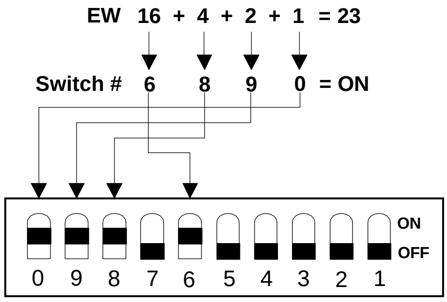


$$GW = \frac{\text{Stroke length + 51mm mounting zone + 46 mm}}{\text{17,9 mm}}$$

- *Put in the values of above sketch*

$$GW = \frac{300 + 51 + 46}{17,9} = 22,18$$

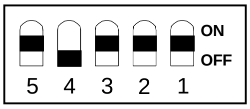
- *Round up that calculated value to 23*
- *Add the Single Values from table 1 to that calculated Total Value of 23 and setup the corresponding dip switches (see table 1) in position* ***ON****. All others in position* ***OFF****.*



- *Table 1 can also be used to obtain the cycle time or measuring frequency for the individual sensor length. The cylcle time is calculated by the addition of the individual cycle times + 6,2 µs.*

5.2 Noise Rejection

TEMPOSONICS sensor device needs a perfect STOP signal. Noises out of interferences on the connecting cable can be rejected on the Analog Board AK 288 with code switch S1 by programming a " time window ". The STOP signal must be within this window.



Code switch S1

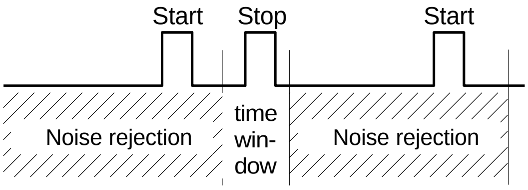
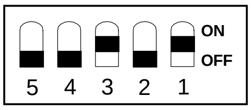


Fig. 9

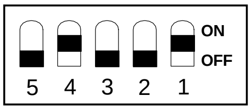
The pulse duration - measured in µs - is adjusted dynamically to the STOP signal in each case. If a setting other than the factory scaling is desired, the duration must be programmed on starting up in dependence on the maximum speed of the position magnet

Following noise rejections has been factory set:

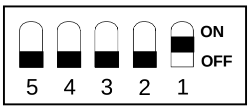
- Stroke length up to 150 mm
  (time window = 3,1 µs)



- Stroke length of 150-300 mm
  (time window = 4,6 µs)



- Stroke length above 300 mm
  (time window = 6,2 µs)



5.2.1 Scaling Noise Rejection

The position of the single switches # 1 - 5 of **S1** is determined according to the formula as follows

$$\textit{Time Window (µsec)} = \frac{\textit{max. speed (m/s)} \times \textit{setup stroke length*} + 17}{7840}$$

*) see page 8; item 5.1

Using this calculated time window, the required programming of **Switch S1**, can read from table below.

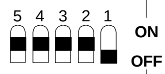
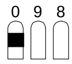
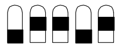
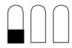
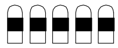
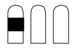
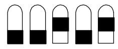
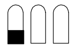
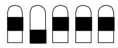
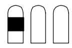
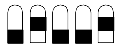
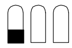
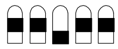
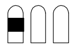
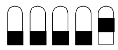
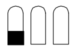
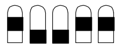
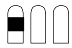
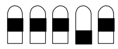
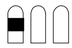
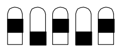
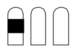
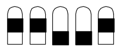
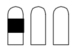
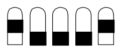
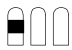
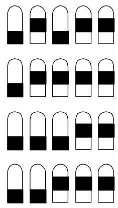
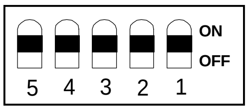
Time window in µs	Switch S1	Switch S2
1) No noise rejection		
2) 1.4 µsec		
3) 1.4 µsec		
4) Factory preset up to 150 mm		
6) 3.1 µsec		
7) Factory preset 150...300 mm		
8) 4.6 µsec		
9) Factory preset above 300 mm		
10) 6.2 µsec		
11) 8.0 µsec		
12) 9.6 µsec		
13) 11.2 µsec		
14) 12.8 µsec		
 ATTENTION! Switch positions as right are prohibited !		

Table 2

If the calculated value is below the lowest table 2 value, switch **S1** is set for a time window = 1.4 µs as follows:



IMPORTANT! Sliding switch **No. 5 of S1** and switch **No. 0 of S2** are connected with one other.
Both sliding switches must be switched ON or OFF!

5.3 Scaling Measuring Direction

The measuring direction is determined or changed on the analog card using the 3 pin code-bridge BR 1 (see page 7).

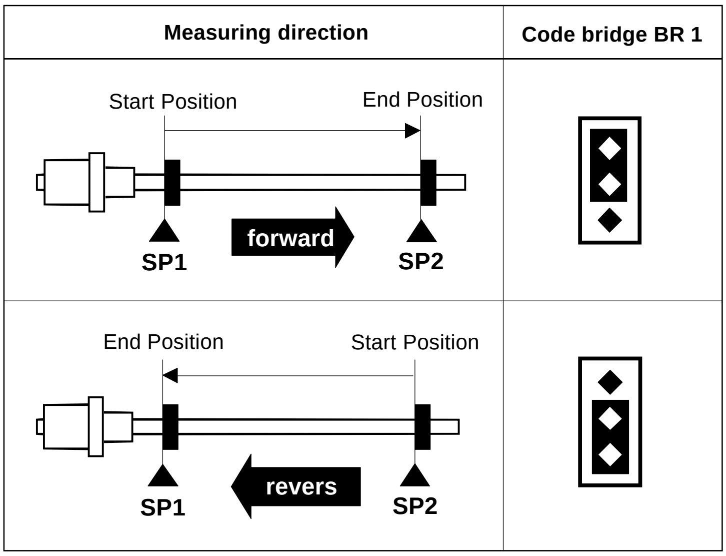


Fig. 10

5.4 Setpoint Adjustment

Independent of measuring direction:
Setpoint SP 1 is always at sensor head
Setpoint SP 2 is always at sensor rod end

For calibration of the Start and End position you need 2 decimal resistors or multispeed helical pot. Setups are done using the resistors **R32** and **R34** (see page 7, fig. 7) as following:

1. Turn potentiometers NULL **" N "** and SPAN **" S "** (page 7, fig 7) to the middle position.

2. For **R32** and **R34** connect compensating resistors in the form of decimal resistors or helical potentiometers.

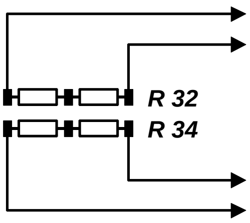


Fig. 11

3. Attention! It is imperative that **R 34** is wired with a resistor (average value appx. 10 KOhms), as the power stages otherwise work without feedback.

4. Connect a Digitalmultimeter to the output of the analog board.

5. Bring the position magnet to the Start Position **SP1** or **SP2** and set the desired output using the decimal resistor or helical potentiometer at **R32**.

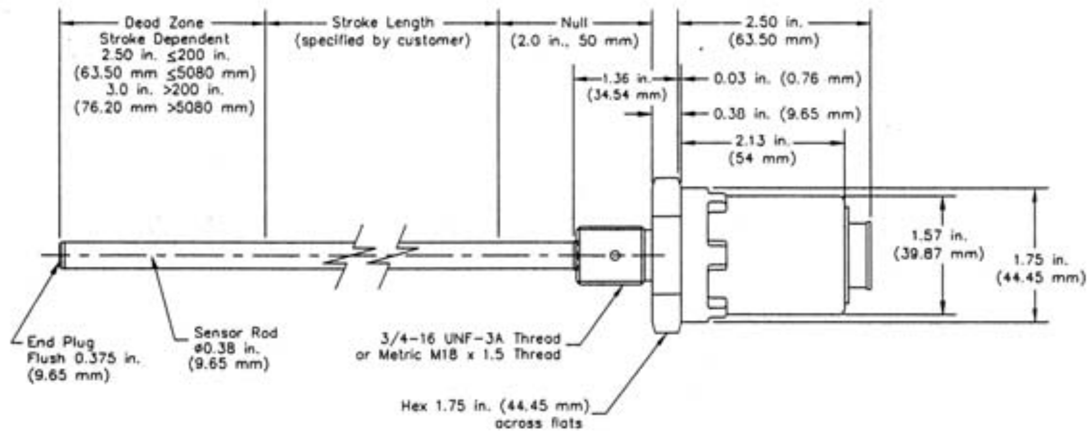
6. Read the resistance value off or measure the potentiometer value and connect as fixed resistor for **R32**

7. Check the output by approaching the start point from both sides several times, and correct where necessary using **" N "**.

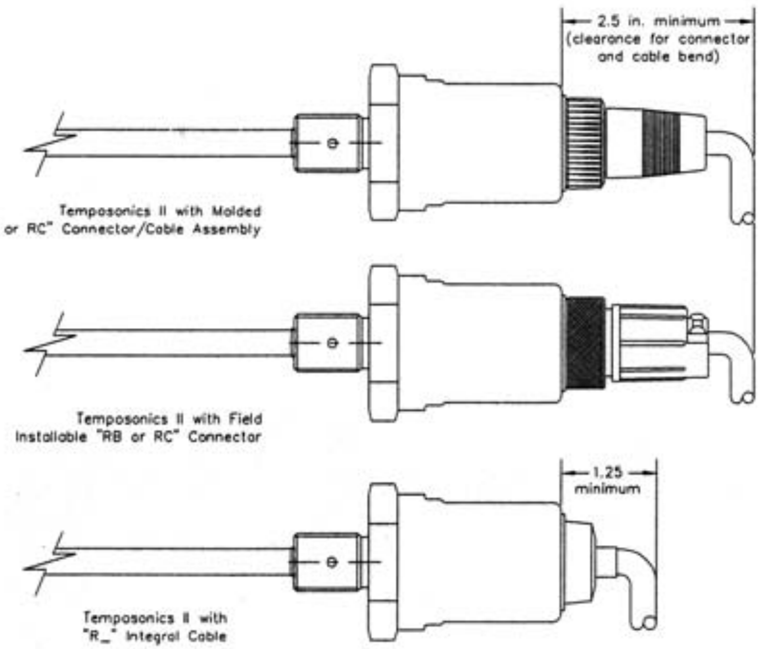
8. Bring the position magnet to the End Position **SP1** or **SP2** and determine the fixed resistance for **R34** in the same manner as described for **R32**.

9. Check the output by approaching the end point from both sides several times, and correct where necessary using **" S "**.

10. If there is only 1 decimal resistor or 1 helical potentiometer, before **R 32** is set, **R 34** must be provided with a **10 KOhms** fixed resistor.



Temposonics II Dimension

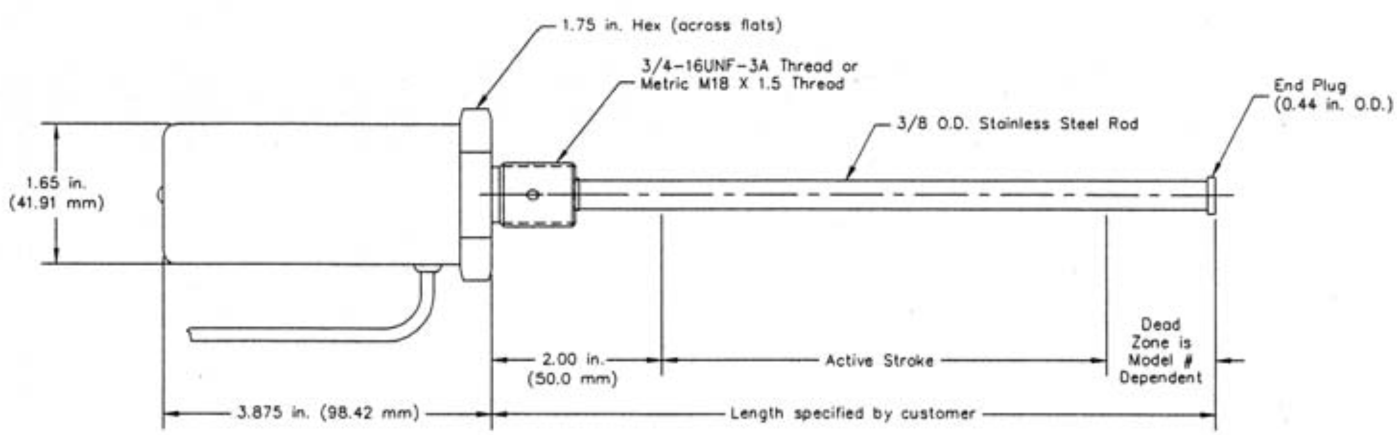


Temposonics II Connector/Cable Clearance Requirements

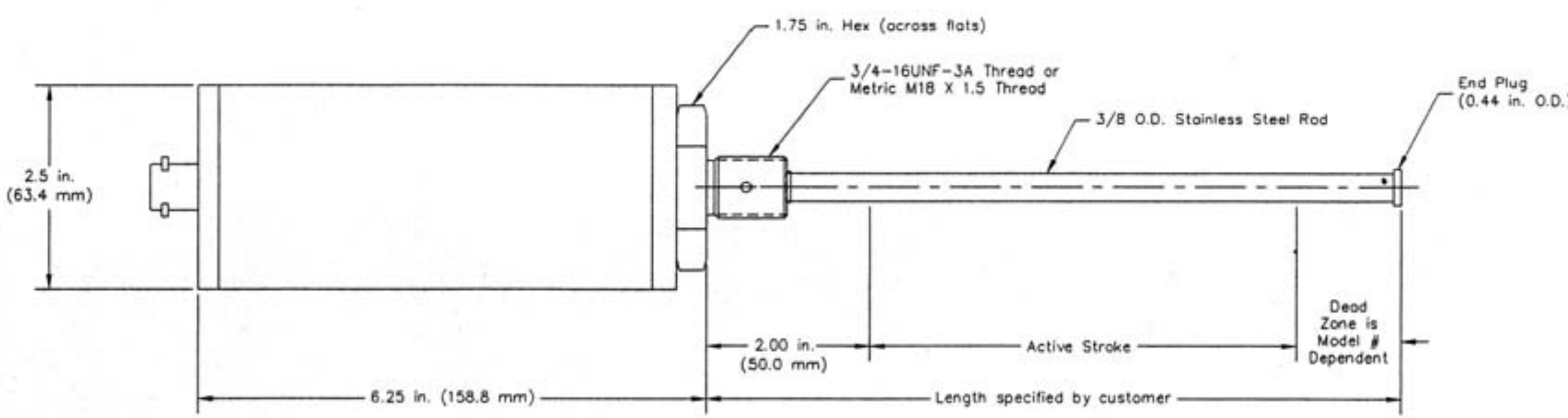
REV.	DATE	ECO #	
B	04/14/99	3792	CHG DEAD ZONE
A	12/02/98	3720	

TITLE
Tempo II Dimension
and Connector Drawing

DWG NO.	SHEET	REV
901009	1 OF 1	B



Tempo I Standard Enclosure (Style '1')

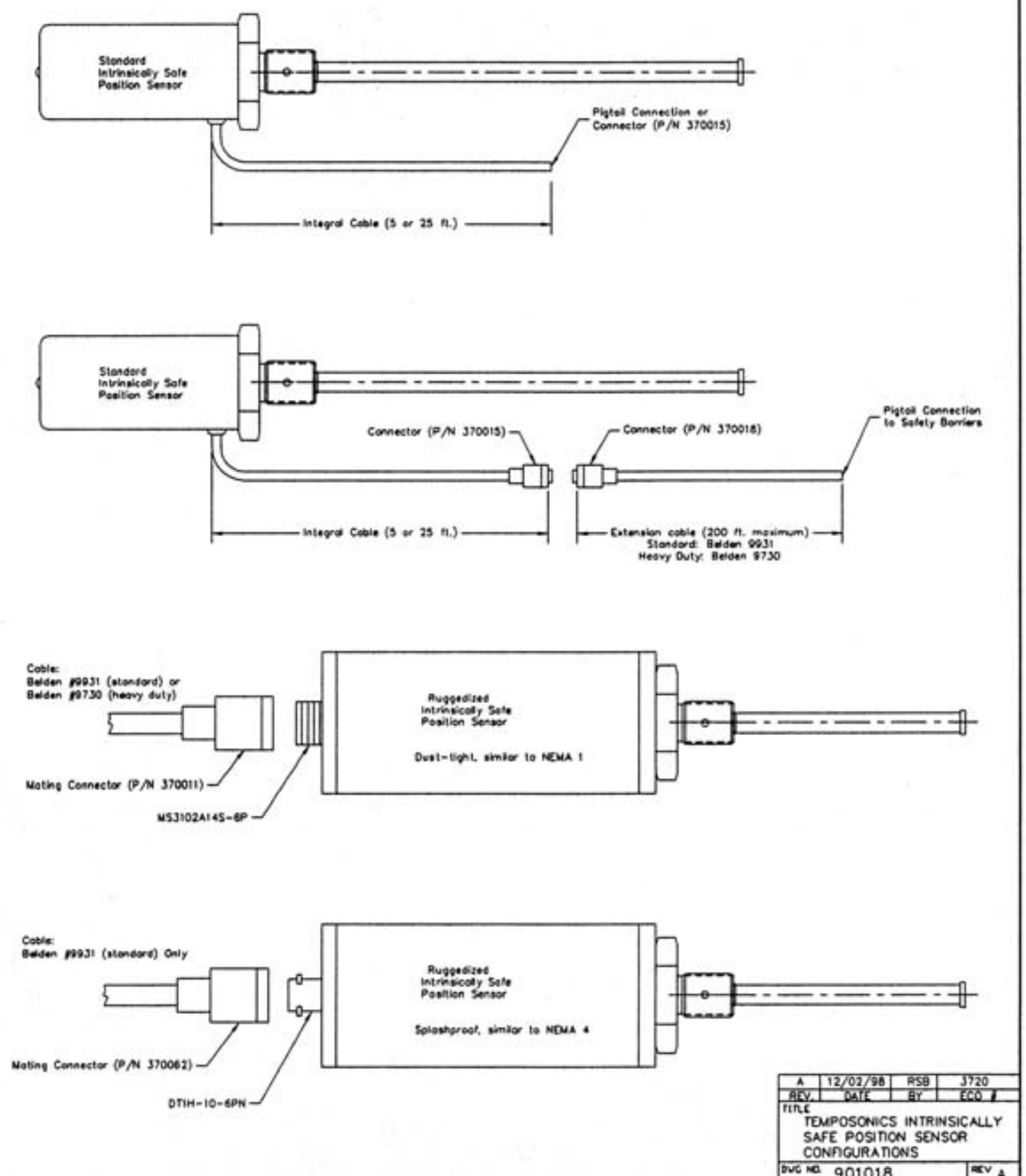


Tempo I Ruggedized Enclosures (Styles '2' & '3')

REV.	DATE	ECO #
A	12/02/98	3720

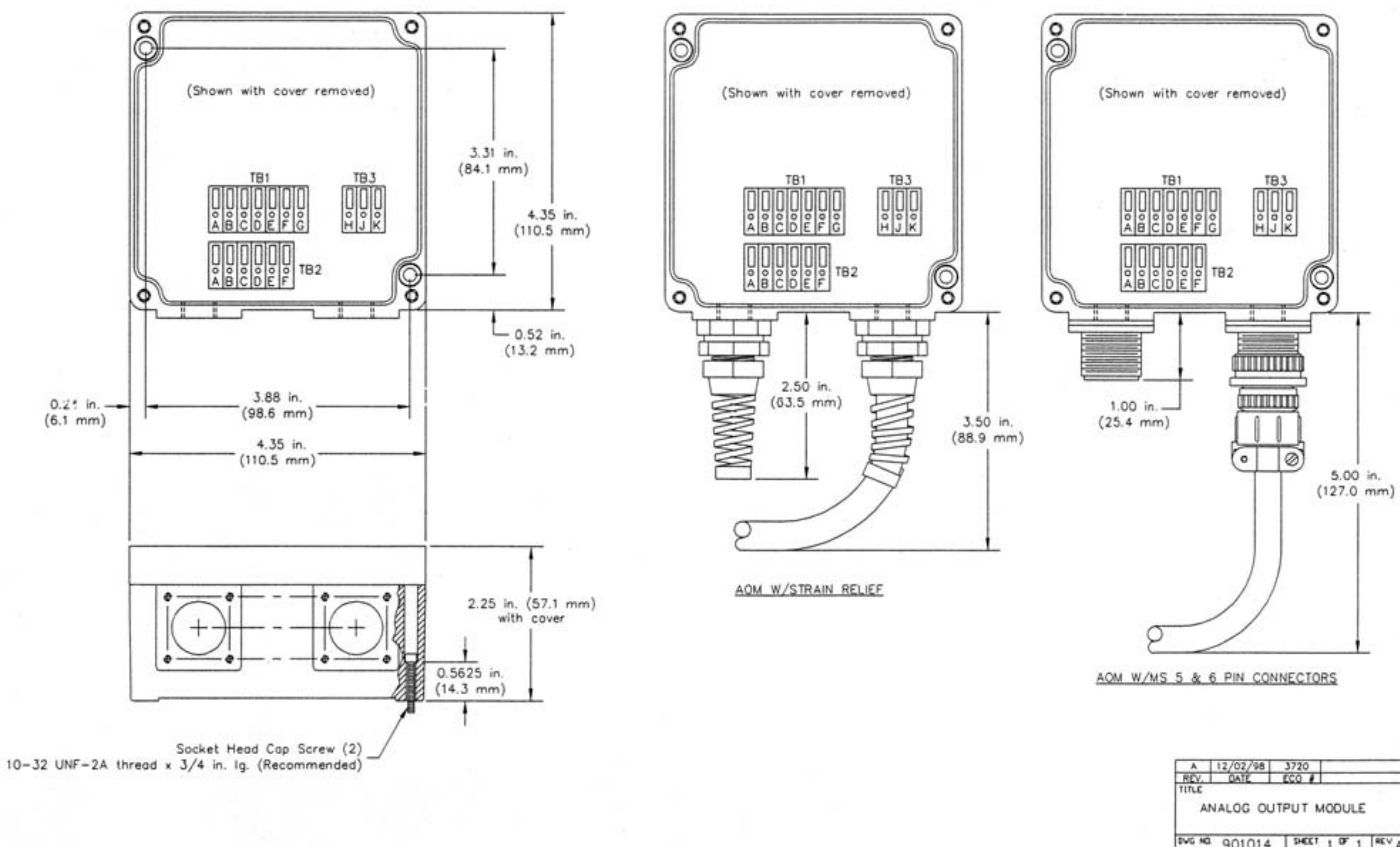
TITLE: Tempo I Dimension Drawing

DWG NO. 901017 | SHEET 1 OF 1 | REV A

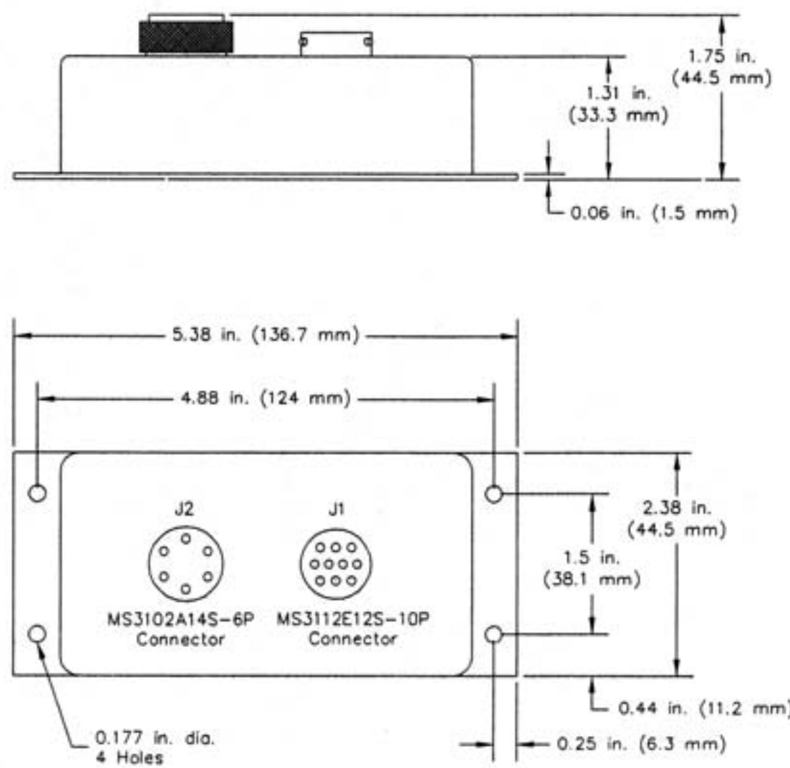

Standard Intrinsically Safe Position Sensor
Pigtail Connection or Connector (P/N 370015)
Integral Cable (5 or 25 ft.)
Standard Intrinsically Safe Position Sensor
Connector (P/N 370015)
Connector (P/N 370018)
Pigtail Connection to Safety Barriers
Integral Cable (5 or 25 ft.)
Extension cable (200 ft. maximum) Standard: Belden 9931 Heavy Duty: Belden 9730
Cable: Belden #9931 (standard) or Belden #9730 (heavy duty)
Ruggedized Intrinsically Safe Position Sensor
Dust-tight, similar to NEMA 1
Mating Connector (P/N 370011)
MS3102A14S-6P
Cable: Belden #9931 (standard) Only
Ruggedized Intrinsically Safe Position Sensor
Splashproof, similar to NEMA 4
Mating Connector (P/N 370062)
DTIH-10-6PN
A 12/02/98 RSB J720
REV. DATE BY ECO #
TITLE
TEMPOSONICS INTRINSICALLY SAFE POSITION SENSOR CONFIGURATIONS
DWG NO. 901018
REV A

ANALOG OUTPUT MODULE

Temposonics® sensors are a registered trademark of MTS Systems Corporation



DIGITAL INTERFACE BOX



J1 MATING CONNECTOR MTS P/N 370013
J2 MATING CONNECTOR MTS P/N 370015

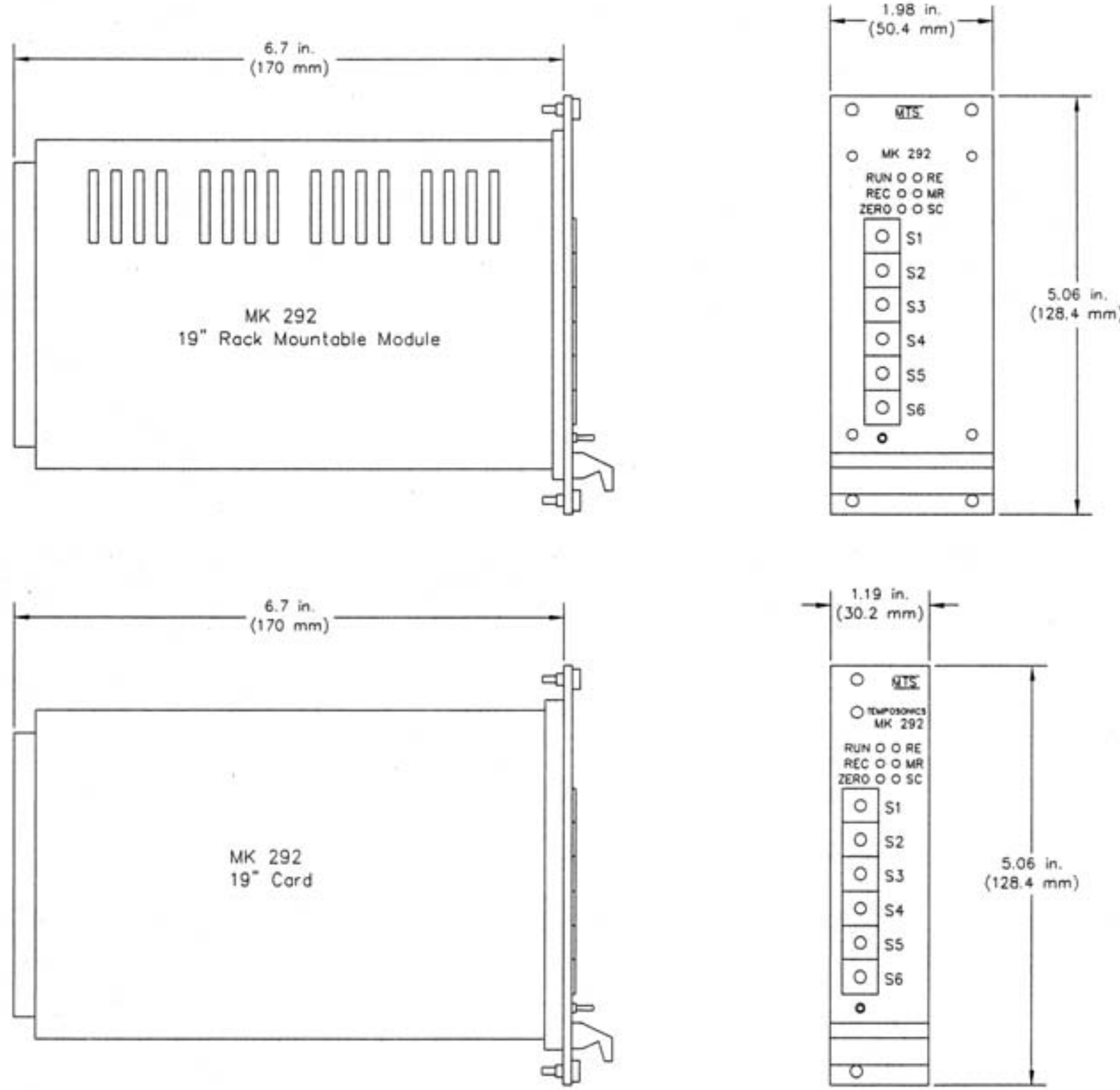
REV.	DATE	ECO #
A	12/02/98	3720

TITLE: DIGITAL INTERFACE BOX

DWG NO. 901015 | SHEET 1 OF 1 | REV A

MK 292 MODULE

Temposonics® sensors are a registered trademark of MTS Systems Corporation

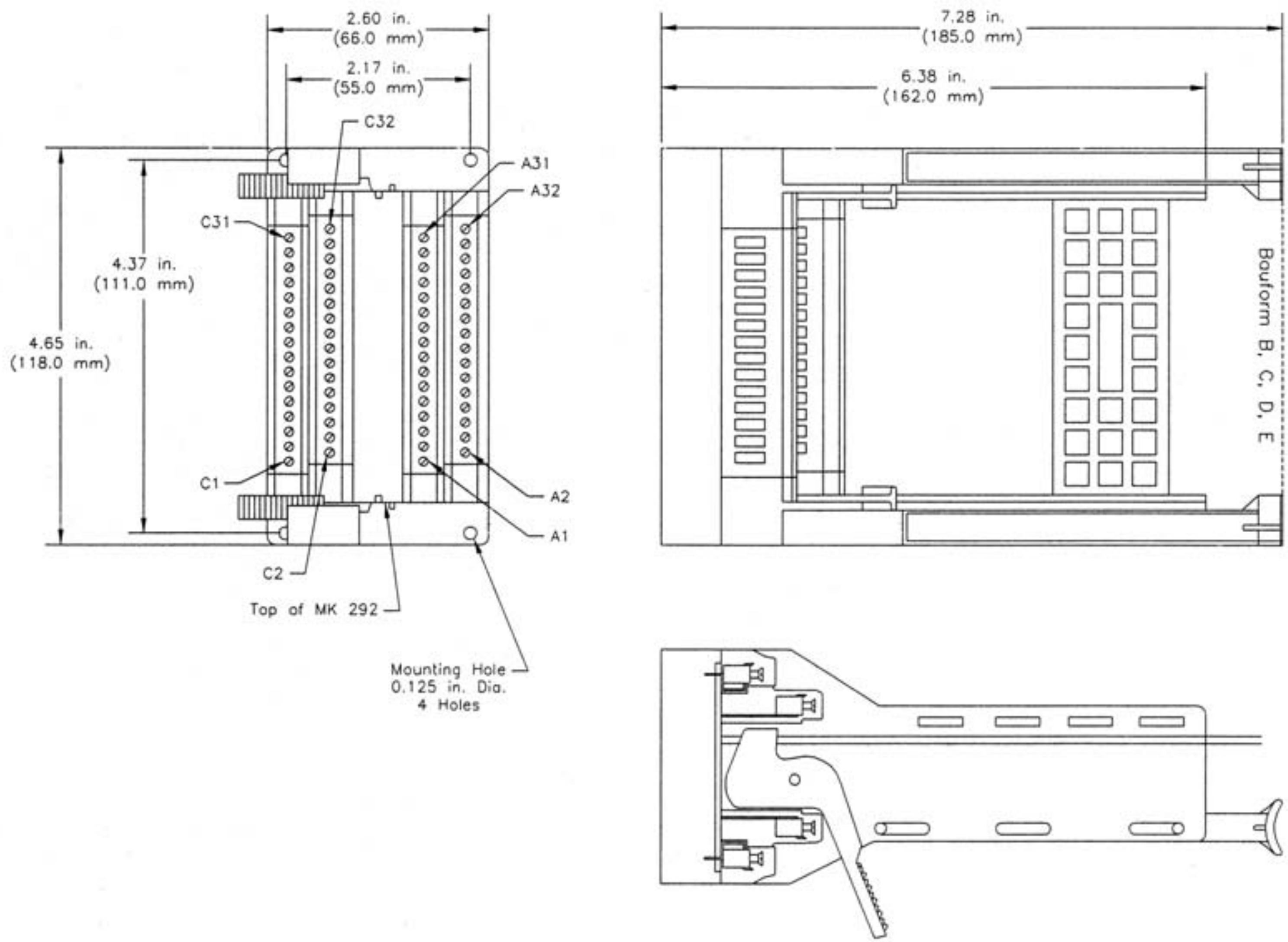


REV.	DATE	ECO #	
C	8/4/99	3856	ADD NOTE FOR CARD ORIENTATION
B	05/04/99	3838	ADD TERMINAL DESIGNATORS
A	12/02/98	3720	INITIAL RELEASE

TITLE: MK 292 MODULE

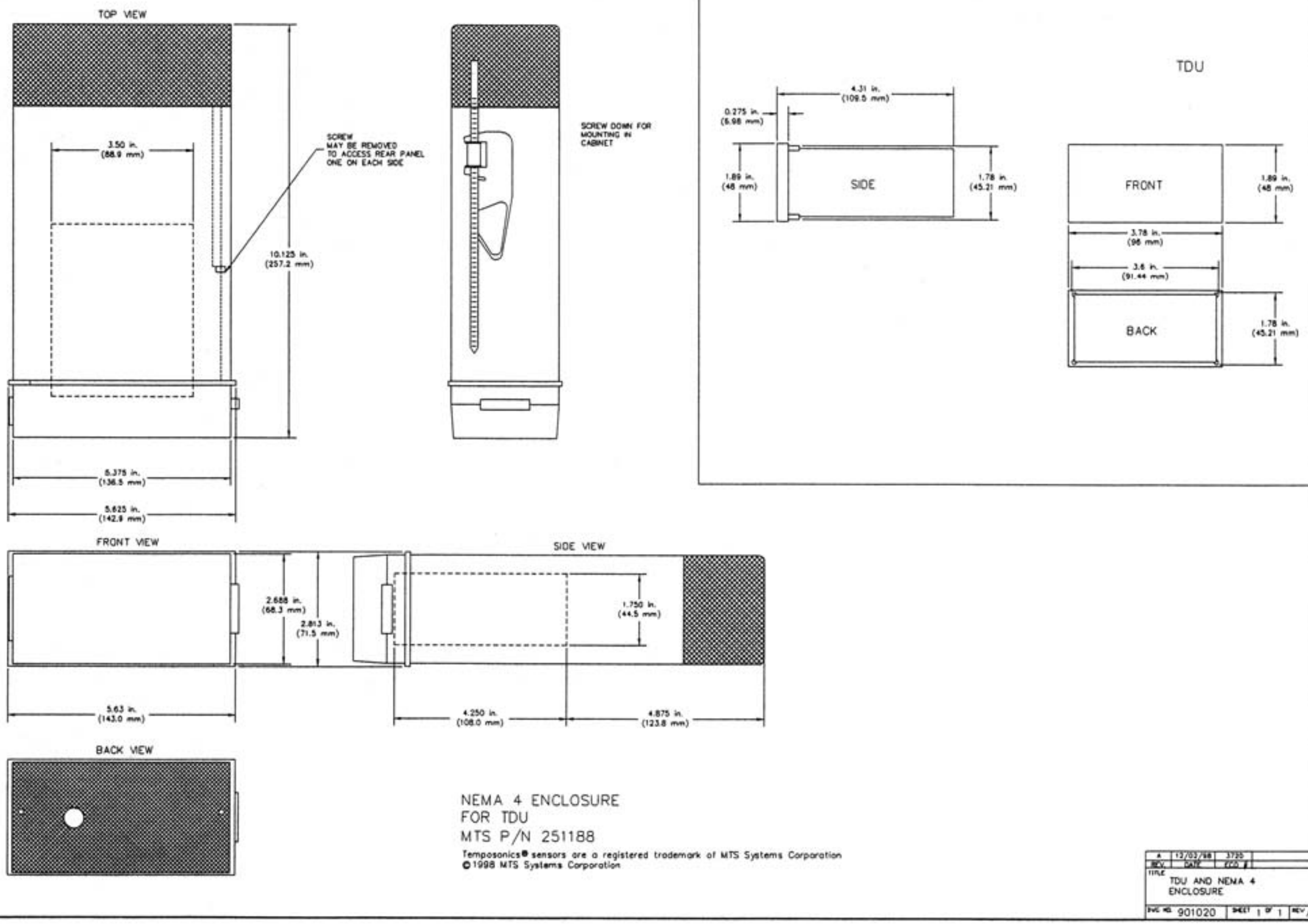
DWG NO. 901019 | SHEET 1 OF 2 | REV C

MK 292 MODULE



MK292 Euro-Card Holder MTS P/N 370292.
Euro-Card Holder for use with board version MK292 only.

REV.	DATE	ECO #
TITLE	MK 292 MODULE	
DWG NO. 901019	SHEET 2 OF 2	REV C



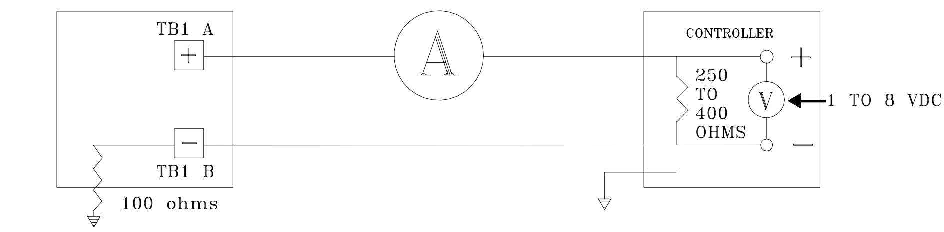
NEMA 4 ENCLOSURE
FOR TDU
MTS P/N 251188

Temposonics® sensors are a registered trademark of MTS Systems Corporation

Temposonics
Technical Notes
Index

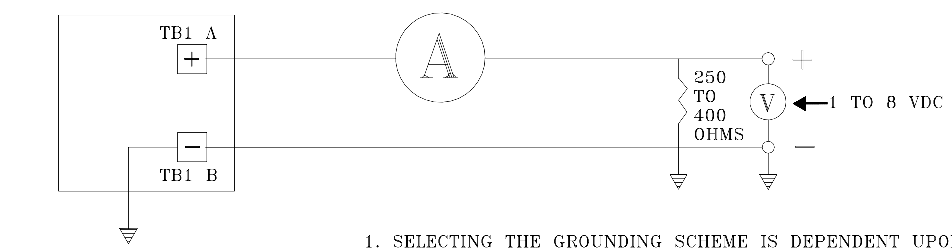
DRAW#	REV	DECRIPTION	CROSS REF	DATE	NAME
APD-0001	A	WIRING OF 4/20mA GND./UNGND.		12/18/1994	DDB
APD-0002	A	TEMPO II PIN OUTS ALL VERSIONS		11/18/1994	DDB
APD-0003	A	CALVERT MFG. CABLE RB TO SRH		11/29/1994	DDB
APD-0004	B	HUSKY RB TO SRH RETRO - PULSE	AP-0109	11/23/1994	DDB
APD-0005	B	HUSKY RB TO SRH RETRO + PULSE	AP-0108	12/1/1994	DDB
APD-0006	A	COE CABLE WIRING TO DIB BOX		11/29/1994	DDB
APD-0007	A	COE CABLE WIRING FOR NEUTER	AP-0106	12/2/1994	DDB
APD-0009	A	TEMPO II ANALOG TO DIGITAL	AP-0103	8/19/1994	DDB
APD-0010	A	TEMPO I ANA./DIG. AB 1771QB	AP-0165	8/19/1994	SM
APD-0011	A	AOM W/EXT. VDC FOR VELOCITY	AP-0022	8/28/1994	SM
APD-0012	A	AOM W/EXT. VDC FOR VELOCITY	AP-0154	8/31/1994	SM
APD-0013	A	MODIF.80 SERIES TSC. TO 60 SERIES	AP-0056	1/1/1995	SM
APD-0014	A	TEMPO II W/DPM & AOM & TEC CARD		1/1/1995	SM
APD-0015	D	TEMPO II ANA./DIG. W/TDC & AOM	AP-0099	1/1/1995	SM
APD-0016	B	HUSKY RB TO SRH RETRO - PULSE	AP-0109	2/20/1995	SM
APD-0017	B	HUSKY RB TO SRH RETRO + PULSE	AP-0108	2/20/1995	SM
APD-0018	A	WIRING LP TO AOM CARD		3/1/1995	DDB
APD-0019	A	WIRING TEMPO I INTRINSI. /AOM		3/1/1995	DDB
APD-0020	A	AOM JUMPERS - /+ INTERROGATION		3/1/1995	DDB
APD-0021	A	MOOG AOM'S: PWM & CONFORMAL		4/21/1996	BKT
APD-0022	A	EXT CABLE & INT CABLE PIN OUT		8/13/1996	BKT
APD-0023	B	MATING CONNECTOR PART NUMBERS	AP1-0001	5/3/1995	DBB
APD-0024	B	SPECS. FOR AOM DUEL CHANNEL	AP1-0002	5/18/1995	DBB
APD-0025	B	DIFFERENCES OLD TCS / NEW MK292 CARD	AP1-0003	5/22/1995	DBB
APD-0026	B	NOTE ON AB 1771 QB AND DPM	AP1-0004	6/12/1995	DBB
APD-0027	C	SPECS. FOR AOM DIFFERENTIAL OUTPUTS	AP1-0005	4/22/1996	DBB
APD-0028	B	SPECS. FOR ANA./DIG. SYSTEMS(TO ORDER)	AP1-0006	5/23/1995	DBB
APD-0029	D	WIRING OF LP TO AOM BOX	AP1-0007	6/15/1995	DBB
APD-0030	C	DISPLACEMENT FLOAT	AP1-0008	5/1/1996	BKT
APD-0031	C	TEMPO III CAPTIVE SLIDE, DUAL CHANNEL	AP1-0009	8/8/1996	RSM
APD-0032	C	TEMPO III RH ROD STYLE, DUAL CHANNEL	AP1-0010	10/15/1996	RSM
APD-0033	B	RETROFITING NEW SE BASED LP	AP1-0011	4/3/1997	RSM
APD-0034	B	RETROFIT OF LA SE BASED SENSORS	AP1-0012	4/4/1997	RSM
APD-0035	B	RETROFIT OF LP SE BASED SENSORS	AP1-0013	4/11/1997	RSM
APD-0036	B	NEMA 4 ENCLOSURE FOR TDU	AP1-0014	4/17/1997	RSM
APD-0037	B	FORMED TRANSDUCER SPEC SHEET	AP1-0015	4/23/1997	RSM
APD-0038	B	SENSOR HEAD AND CONNECTION LENGTH	AP1-0016	8/27/1997	RSM
APD-0039	B	SENSOR COMPARISON	AP1-0017	8/27/1997	RSM
APD-0040	B	L-SERIES MEASUREMENTS	AP1-0018	8/27/1997	RSM
APD-0041	B	PLUG-IN ANALOG OUTPUT CARD WITH LP	MPDC-0030	9/26/1997	RMP
APD-0042	B	CUSTOM SETPOINTS RH / LH ANALOG		1/12/2000	KLP
APD-0043	B	2 MAGNET CUSTOM SETPOINTS RH ANALOG		10/8/1999	KLP
APD-0044	A	CUSTOM SETPOINTS PB ANALOG		10/8/1999	KLP
APD-0045	A	2 MAGNET CUSTOM SETPOINTS PB ANALOG		10/8/1999	KLP
APD-0046	A	OLD T 2 TRIM PROCEDURE FOR REPAIR CENTERS		7/7/2000	MO'G
APD-0047	A	Configuring R Series Fieldbus Sensors		12/6/2001	RL
APD-0048	A	Adjustment Procedure for the Set Slave Address Command for the Profibus P202 (Husky) Sensor		12/13/2001	UV

4-20 mA UNGROUNDED LOOP



ANALOG OUTPUT MODULE

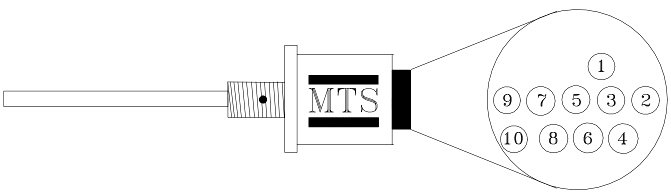
4-20 mA GROUNDED LOOP



ANALOG OUTPUT MODULE

1. SELECTING THE GROUNDING SCHEME IS DEPENDENT UPON THE CONTROLLER INTERFACE.
2. THE CURRENT LOOP PATH MUST BE COMPLETED FOR THE SYSTEM TO OPERATE.
3. THE UNGROUNDED VERSION IS NOT TRULY ISOLATED FROM GROUND. ISOLATORS ARE REQUIRED IF THIS CONFIGURATION IS NEEDED BY THE CONTROLLER INTERFACE.

MTS® Sensors Division	A SIZE	DRAWING NUMBER	APD-0001	DATE 11/18/94
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION A	ORIGINATOR	DAVE BAKER



PIN NUMBERING/SOCKET SIDE
(VIEW FROM TOP OF TRANSDUCER)

WARNING

1. INTERROGATION PULSE SHOULD BE A PULSE DURATION OF 1 uS.

   ONE INPUT MUST BE GROUNDED FOR A SINGLE INTERROGATION.

   BOTH INPUTS MUST BE USED FOR DUAL INTERROGATION
2. USED FOR A TEMPO II WITH A DPM SET FOR EXTERNAL INTERROGATION.

PIN #	WIRE COLOR (STRIPED)	WIRE COLOR (SOLID)	NEUTER	WITH DPM	WITH APM	WITH RPM
1	WHITE/BLUE	WHITE	DC GROUND	DC GROUND	DC GROUND	DC GROUND
2	BLUE/WHITE	BROWN	FRAME	FRAME	FRAME	FRAME
3	WHITE/ORANGE	GRAY	NOT USED	(−) GATE	DISP GND	(−) START/STOP
4	ORANGE/WHITE	PINK	NOT USED	(+) GATE	DISP OUT	(+) START/STOP
5	WHITE/GREEN	RED	(+) 15VDC	(+) 15VDC	(+) 15VDC	(+) 15VDC
6	GREEN/WHITE	BLUE	(−) 15VDC	(−) 15VDC	(−) 15VDC	(−) 15VDC
7	WHITE/BROWN	BLACK	RET GROUND	NOT USED	NOT USED	NOT USED
8	BROWN/WHITE	VIOLET	RET PULSE	NOT USED	NOT USED	NOT USED
9	WHITE/GRAY	YELLOW	(+) INT 1	(+) INT 1&2	NOT USED	(+) INT 1
10	GRAY/WHITE	GREEN	(−) INT 1	(−) INT 1&2	NOT USED	(−) INT 1

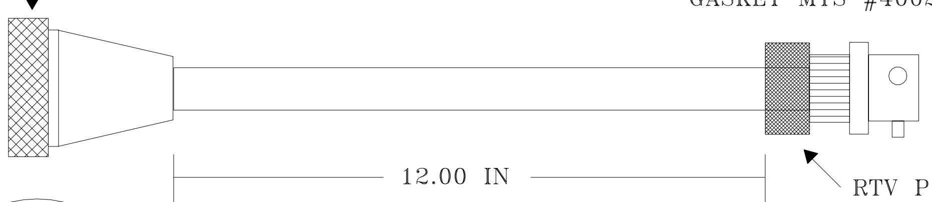
MTS Sensors Division®	A SIZE	DRAWING NUMBER APD−0002		DATE 11/18/94
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION B	ORIGINATOR DAVE BAKER	

CALVERT MANUFACTURING

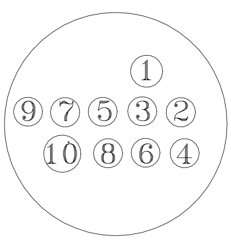
MT STYLE CONNECTOR
(MATES TO RB STYLE)

MTS #370012 MS3112E-12-10P

MATING CONNECTOR
MTS #370013 MS3116F-12-10S
GASKET MTS #400231



RTV POTTING 112



TEMPOSONICS II TRANSDUCER WITH EXTERNAL INTERROGATION DPM

PIN # FROM TEMPO II	PIN OUT FOR MTS# 370012	COLOR CABLE	FUNCTIONAL DESCRIPTION
PIN 1	A	WHITE	DC GROUND
PIN 2	J	BROWN	FRAME
PIN 3	K	GRAY	(−) GATE
PIN 4	G	PINK	(+) GATE
PIN 5	H	RED	+ 15 VDC
PIN 6	B	BLUE	− 15 VDC
PIN 7	NOT USED	BLACK	NOT USED
PIN 8	NOT USED	VIOLET	NOT USED
PIN 9	E	YELLOW	(+) INTERROGATE
PIN 10	D	GREEN	(−) INTERROGATE

MTS® Sensors Division	A SIZE	DRAWING NUMBER APD-0003		DATE 11/29/94
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION A	ORIGINATOR	DAVE BAKER

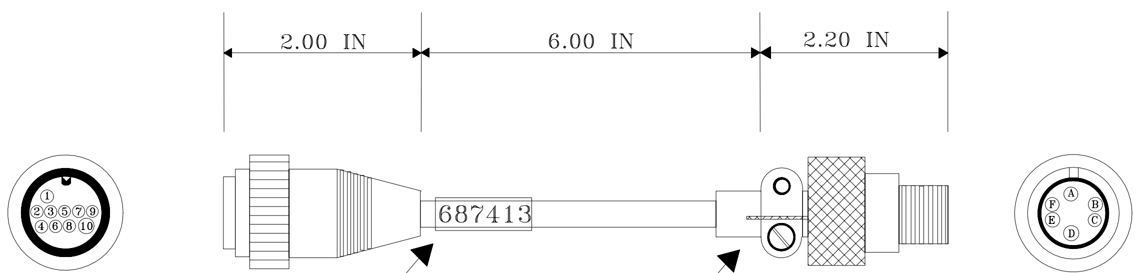
COMPANY: HUSKY PART # 687413

SUBJECT: TEMPOSONICS II REPLACEMENT CABLE
RETROFITTING THE SRH NEMA 4
ENCLOSURE

REF: RETROFIT CABLE FOR AOM'S
12 INCHES OR LESS

PIN/CONDUCTOR ASSIGNMENTS

WIRE PAIRS	FROM P1	NEUTER	TO P2
WHITE	1	GROUND	B
BROWN	2	FRAME	NOTE
GRAY	3	N/C	N/C
PINK	4	N/C	N/C
RED	5	VCC	A
BLUE	6	VEE	D
BLACK	7	RET GND	B
VIOLET	8	RET OUT	C
YELLOW	9	+ INT	B
GREEN	10	− INT	E



MOLDED

ID label constructed of embossing tape (approx. 1.25") and heat shrink (approx. 1.25")

DRAIN WIRE TWISTED WITH BROWN WIRE MAKING CONTACT TO THE ID OF THE CABLE CLAMP.

MS3101A14S-6P
(370018)

OBSOLETE − SUPERCEEDED BY MPDC-0035

M.PUTNAM 7/23/96

NOTE: TWIST THE SHIELD (DRAIN) WIRE AND THE FRAME WIRE TOGETHER (THIS TWISTED PAIR MUST BE BETWEEN THE CABLE CLAMP AND THE BOOT AND NOT TERMINATED)

Rev. B: Added Husky part # to cable, BKT, 5/7/96

MTS® Sensors Division	A SIZE	DRAWING NUMBER APD−0004		
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION B	ORIGINATOR DAVE BAKER	11/23/94

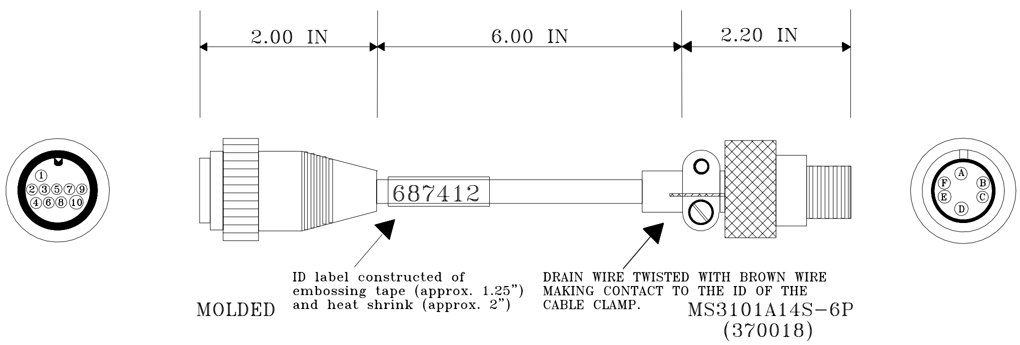
COMPANY: HUSKY PART # 687412

SUBJECT: TEMPOSONICS II REPLACEMENT CABLE
RETROFITTING THE SRH NEMA 4
ENCLOSURE

REF: RETROFIT CABLE FOR AOM'S
GREATER THAT 12 INCHES

PIN/CONDUCTOR ASSIGNMENTS

WIRE PAIRS	FROM P1	NEUTER	TO P2
WHITE	1	GROUND	B
BROWN	2	FRAME	NOTE
GRAY	3	N/C	N/C
PINK	4	N/C	N/C
RED	5	VCC	A
BLUE	6	VEE	D
BLACK	7	RET GND	B
VIOLET	8	RET OUT	C
YELLOW	9	+ INT	E
GREEN	10	- INT	B



NOTE: TWIST THE SHIELD (DRAIN) WIRE AND THE FRAME WIRE TOGETHER
(THIS TWISTED PAIR MUST BE BETWEEN THE CABLE CLAMP AND THE BOOT
AND NOT TERMINATED)

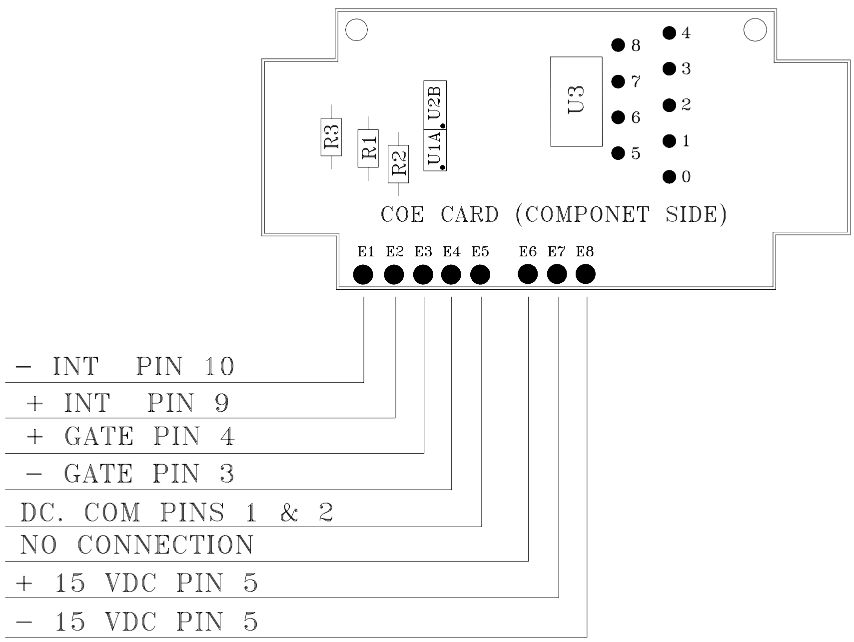
OBSOLETE - SUPERCEEDED BY MPDC-0036

M.PUTNAM 7/23/96

Rev. B Added Husky part # to cable, BKT, 5/7/96

MTS® Sensors Division	A SIZE	DRAWING NUMBER	APD-0005	
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION B	ORIGINATOR DAVE BAKER	12/01/94

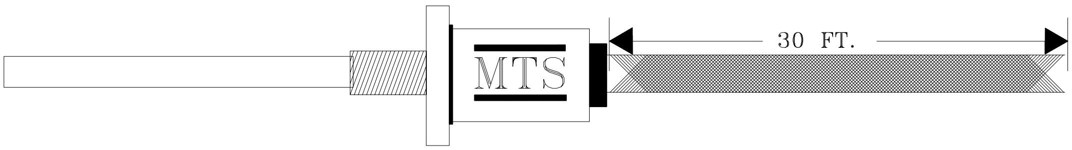
BYPASSING COE CARD WITH TEMPO II WITH DPM



MTS® Sensors Division	A SIZE	DRAWING NUMBER APD−0006	DATE 11/29/94
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION A	ORIGINATOR DAVE BAKER

SPECIAL COE CABLE FOR TEMPO II

CABLE SPECIFICATIONS: INDIVIDUAL SHIELDED PAIR, 20 AWG, OVERALL 36 AWG WOVEN 90% SHIELD, BLACK OUTER JACKET ESTANE #58866, COE PART #203-0059-01. MTS #400901.



CABLE: SEE ABOVE.

SHIELD: CONNECT EXTENSION CABLE SHIELD AT J2 PIN-B

NOTE 1: FRAME GROUND IS ISOLATED FROM CIRCUIT GROUND INSIDE THE TRANSDUCER HEAD.

NOTE 2: FOR RETROFITTING DIB'S WITH STROKES GREATER THAN 12 INCHES (+INTERROGATION)

NOTE 3: FOR RETROFITTING DIB'S WITH STROKES LESS THAN 12 INCHES (- INTEROGATION), REVERSE PINS 9&10.

NOTE 4: INTERROGATION IS 1uS, ONE INPUT MUST BE GROUNDED FOR SINGLE INTERROGATION, BOTH FOR DUEL.

NOTE 5: USED FOR A TEMPO II WITH A DPM SET FOR EXTERNAL INTERROGATION.

PIN NO.	WIRE COLOR PAIR	NEUTER	DPM	WIRE COLOR
4 3	WHITE/BLACK	+ GATE - GATE	+ GATE - GATE	WHITE BLACK
5 1	RED/BLACK	+ 15VDC DC COMM	+ 15VDC DC COMM	RED BLACK
6 2	YELLOW/BLACK	- 15VDC FRAME(1)	- 15VDC FRAME(1)	YELLOW BLACK
8 7	GREEN/BLACK	RET PULS NOT USED	NOT USED NOT USED	GREEN BLACK
9 10	BLUE/BLACK	+ INT(4) - INT(4)	+INT(4&5) -INT(4&5)	BLUE BLACK

OBSOLETE - SUPERCEEDED BY MPDC- 0039

M.PUTNAM 7/23/96

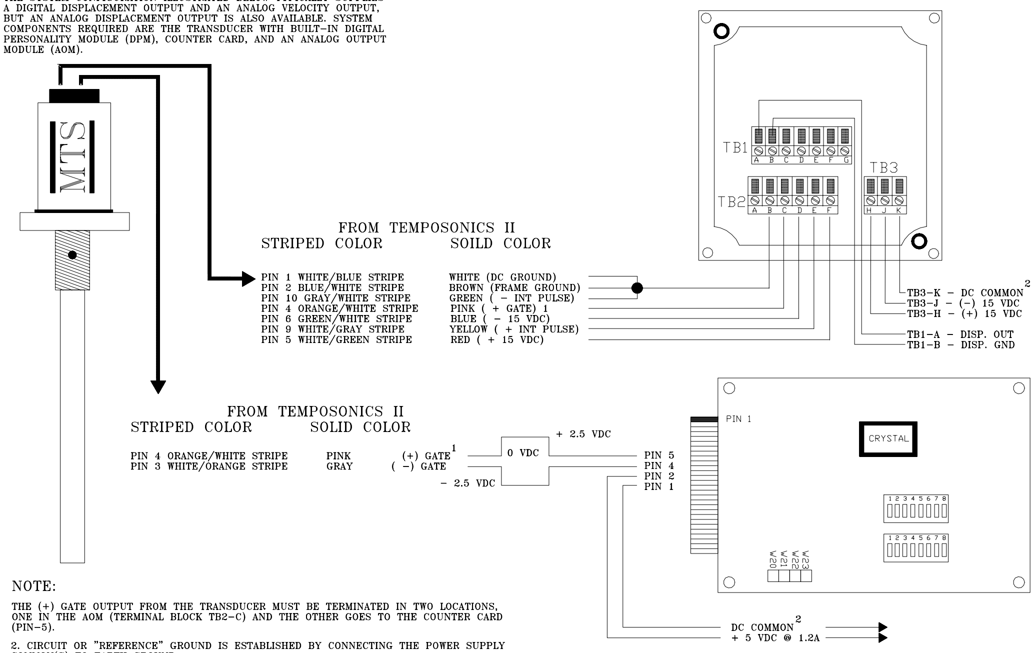
Rev. B: Delete incorrect Beldon cable #

MTS® Sensors Division	A SIZE	DRAWING NUMBER APD-0007	DATE 04/12/96
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION B	ORIGINATOR DAVE BAKER

ANALOG/DIGITAL SYSTEM CONFIGURATION WITH TEMPOSONICS II TRANSDUCER

THE SYSTEM CONFIGURATION ILLUSTRATED BELOW TYPICALLY SUPPLIES A DIGITAL DISPLACEMENT OUTPUT AND AN ANALOG VELOCITY OUTPUT, BUT AN ANALOG DISPLACEMENT OUTPUT IS ALSO AVAILABLE. SYSTEM COMPONENTS REQUIRED ARE THE TRANSDUCER WITH BUILT-IN DIGITAL PERSONALITY MODULE (DPM), COUNTER CARD, AND AN ANALOG OUTPUT MODULE (AOM).

TEMPOSONICS II CONNECTIONS TO ANALOG OUTPUT MODULE (AOM) WITH STRAIN RELIEF CONNECTORS

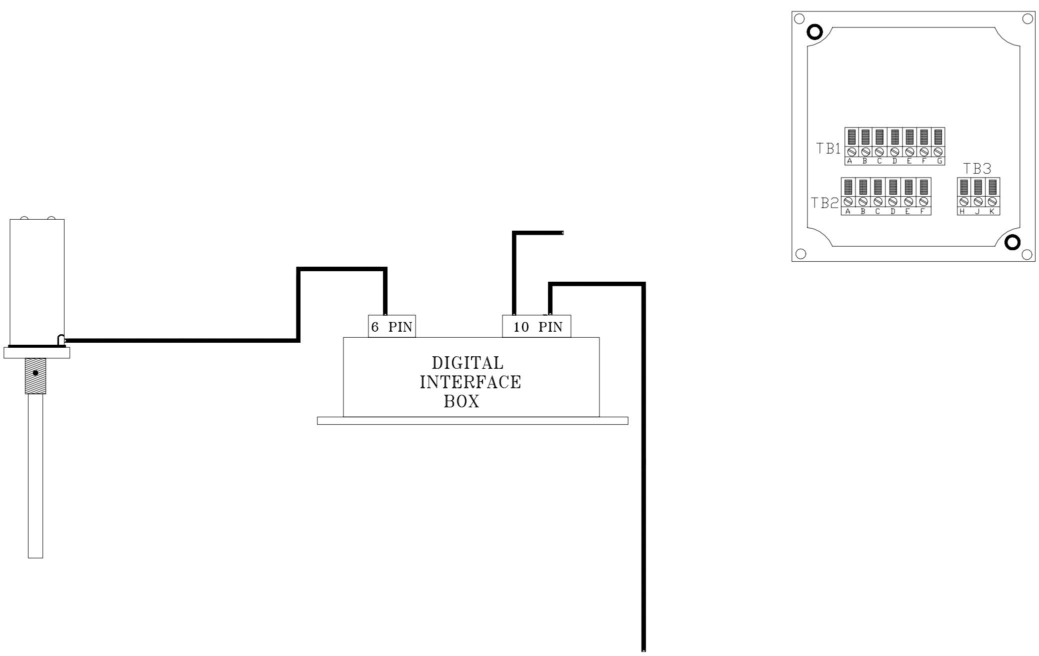


NOTE:

THE (+) GATE OUTPUT FROM THE TRANSDUCER MUST BE TERMINATED IN TWO LOCATIONS, ONE IN THE AOM (TERMINAL BLOCK TB2-C) AND THE OTHER GOES TO THE COUNTER CARD (PIN-5).

2. CIRCUIT OR "REFERENCE" GROUND IS ESTABLISHED BY CONNECTING THE POWER SUPPLY COMMON(S) TO EARTH GROUND

MTS Sensors Division ®	A SIZE	DRAWING NUMBER APD-0009		DATE 1/10/95
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION A	ORIGINATOR DAVE BAKER	



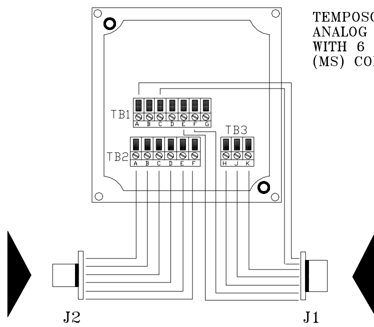
MTS® Sensors Division	A SIZE	DRAWING NUMBER APD-0010	DATE 1/11/95
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION A	ORIGINATOR DAVE BAKER

SUBJECT: WIRING CONFIGURATION FOR AN ANALOG OUTPUT MODULE WITH EXTERNAL VOLTAGE REQUIREMENTS FOR VELOCITY

TEMPOSONICS II CONNECTIONS TO ANALOG OUTPUT MODULA (AOM) WITH 6 & 10 PIN MILITARY STYLE (MS) CONNECTORS.

FROM TEMPOSONICS II

STRIPED COLOR	SOLID COLOR			
PIN 1 WHITE/BLUE STRIPE	WHITE	(GROUND)	NO CONN	A
PIN 2 BLUE/WHITE STRIPE	BROWN	(FRAME GND.)	TB2-B	B
PIN 7 WHITE/BROWN STRIPE	BLACK	(AMP. GND.)		
PIN 8 BROWN/WHITE STRIPE	VIOLET	(RET. PULSE)	TB2-C	C
PIN 6 GREEN/WHITE STRIPE	BLUE	(-15 VDC)	TB2-D	D
PIN 9 WHITE/GRAT STRIPE	YELLOW	(+ INTERRO.)	TB2-E	E
PIN 5 WHITE/GREEN STRIPE	RED	(+12 VDC)	TB2-F	F



J2
6 PIN CONNECTOR
(MS3102A-14S-6P)

J1
10 PIN CONNECTOR
(MS3112E12-10P)

A +15 VDC (TB3-H)
B -15 VDC (TB3-J)
C GROUND (TB3-K)
D + DISP OUT (TB1-A)
E + VELO OUT (TB1-C)
F +24 VDC (TB1-F)
G -24 VDC (TB1-E)

SPECIFICATIONS:

OBSOLETE
SEE mpg DRAWING
7/29/96

ENCLOSURE STYLE:
6 & 10 PIN MS CONNECTORS

DISPLACEMENT OUTPUT:
0 TO 10 VDC

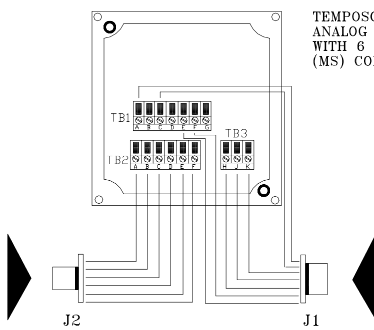
VELOCITY OUTPUT:
MINIMUM: 1"/SEC=.798 VDC
MAXIMUN: 25"/SEC=19.95 VDC
FORWARD ACTING

POWER REQUIREMENTS:
+15 VDC & +24 VDC
(CUSTOMER SUPPLIED)

TEMPOSONICS I CONNECTIONS TO ANALOG OUTPUT MODULA (AOM) WITH 6 & 10 PIN MILITARY STYLE (MS) CONNECTORS.

FROM TEMPOSONICS I

GREEN (+12 TO +14.5 VDC)	TB2-A	A
BLACK (DC COMMON/GND.)	TB2-B	B
BROWN OR ORANGE (RET. PULSE)	TB2-C	C
BLUE (-13.5 TO -15.5 VDC)	TB2-D	D
WHITE (INTERROGATION PULSE)	TB2-E	E
RED (+11.5 TO +12 VDC)	TB2-F	F



J2
6 PIN CONNECTOR
(MS3102A-14S-6P)

J1
10 PIN CONNECTOR
(MS3112E12-10P)

A +15 VDC (TB3-H)
B -15 VDC (TB3-J)
C GROUND (TB3-K)
D + DISP OUT (TB1-A)
E + VELO OUT (TB1-C)
F +24 VDC (TB1-F)
G -24 VDC (TB1-E)

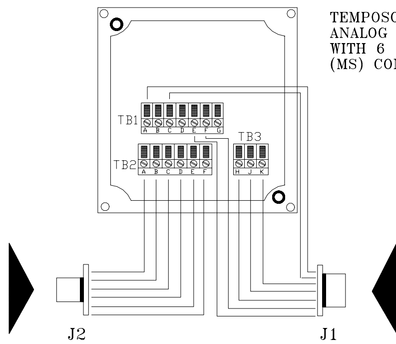
MTS® Sensors Division	A SIZE	DRAWING NUMBER APD-0011	DATE 1/16/95
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION A	ORIGINATOR DAVE BAKER

SUBJECT: WIRING CONFIGURATION FOR AN ANALOG OUTPUT MODULE WITH EXTERNAL VOLTAGE REQUIREMENTS FOR VELOCITY

TEMPOSONICS II CONNECTIONS TO ANALOG OUTPUT MODULA (AOM) WITH 6 & 10 PIN MILITARY STYLE (MS) CONNECTORS.

FROM TEMPOSONICS II

	STRIPED COLOR	SOLID COLOR			
PIN 1	WHITE/BLUE STRIPE	WHITE	(GROUND)	NO CONN	A
PIN 2	BLUE/WHITE STRIPE	BROWN	(FRAME GND.)	TB2-B	B
PIN 7	WHITE/BROWN STRIPE	BLACK	(AMP. GND.)		
PIN 8	BROWN/WHITE STRIPE	VIOLET	(RET. PULSE)	TB2-C	C
PIN 6	GREEN/WHITE STRIPE	BLUE	(-15 VDC)	TB2-D	D
PIN 9	WHITE/GRAT STRIPE	YELLOW	(+ INTERRO.)	TB2-E	E
PIN 5	WHITE/GREEN STRIPE	RED	(+12 VDC)	TB2-F	F



6 PIN CONNECTOR
(MS3102A-14S-6P)

10 PIN CONNECTOR
(MS3112E12-10P)

A +15 VDC (TB3-H)
B -15 VDC (TB3-J)
C GROUND (TB3-K)
D + DISP OUT (TB1-A)
E + VELO OUT (TB1-C)
F +24 VDC (TB1-F)
G -24 VDC (TB1-E)

SPECIFICATIONS:

OBSOLETE SEE mpd W/ M.Putnam

ENCLOSURE STYLE:
6 & 10 PIN MS CONNECTORS

DISPLACEMENT OUTPUT:
0 TO 10 VDC

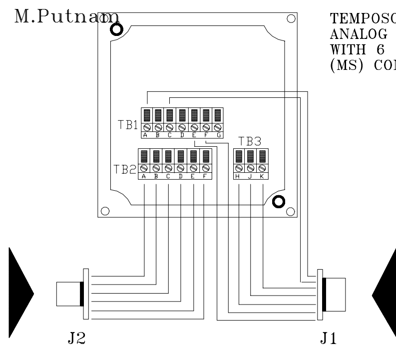
VELOCITY OUTPUT:
MINIMUM: 1"/SEC=1.596 VDC
MAXIMUN: 10"/SEC=15.96 VDC
FORWARD ACTING

POWER REQUIREMENTS:
+15 VDC & +24 VDC
(CUSTOMER SUPPLIED)

TEMPOSONICS I CONNECTIONS TO ANALOG OUTPUT MODULA (AOM) WITH 6 & 10 PIN MILITARY STYLE (MS) CONNECTORS.

FROM TEMPOSONICS I

GREEN (+12 TO +14.5 VDC)	TB2-A	A
BLACK (DC COMMON/GND.)	TB2-B	B
BROWN OR ORANGE (RET. PULSE)	TB2-C	C
BLUE (-13.5 TO -15.5 VDC)	TB2-D	D
WHITE (INTERROGATION PULSE)	TB2-E	E
RED (+11.5 TO +12 VDC)	TB2-F	F



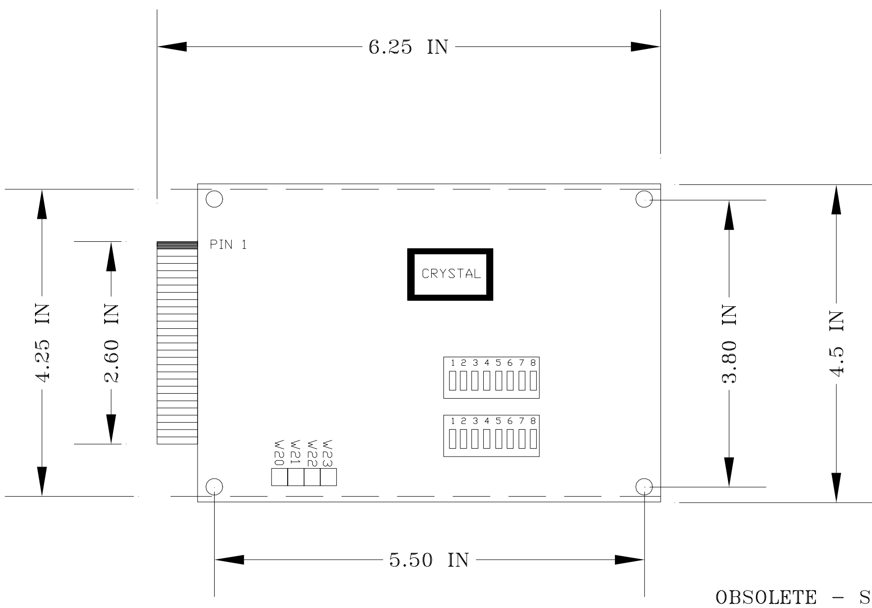
6 PIN CONNECTOR
(MS3102A-14S-6P)

10 PIN CONNECTOR
(MS3112E12-10P)

A +15 VDC (TB3-H)
B -15 VDC (TB3-J)
C GROUND (TB3-K)
D + DISP OUT (TB1-A)
E + VELO OUT (TB1-C)
F +24 VDC (TB1-F)
G -24 VDC (TB1-E)

MTS® Sensors Division	A SIZE	DRAWING NUMBER APD-0012	DATE 1/16/95
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION A	ORIGINATOR DAVE BAKER

PROCEDURE TO MODIFY THE 80 SERIES COUNTER CARD, WHICH HAS A WIDTH OF 4.5", TO THE DEMENSION OF THE 60 SERIES COUNTER CARD (4.25")



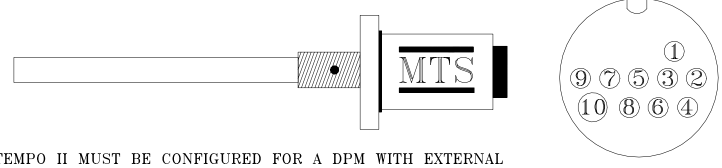
OBSOLETE - SUPERCEEDED
BY MPDC-0040
M.PUTNAM 7/23/96

SAW 0.125" FROM EACH SIDE OF THE COUNTER CARD, AS INDICATED ABOVE, TAKING CAUTION NOT TO DAMAGE ANY LANDS.

SMOOTH THE TRIMMED EDGES TO MAINTAIN AESTHETIC QUALITY AND STRAIGHTNESS.

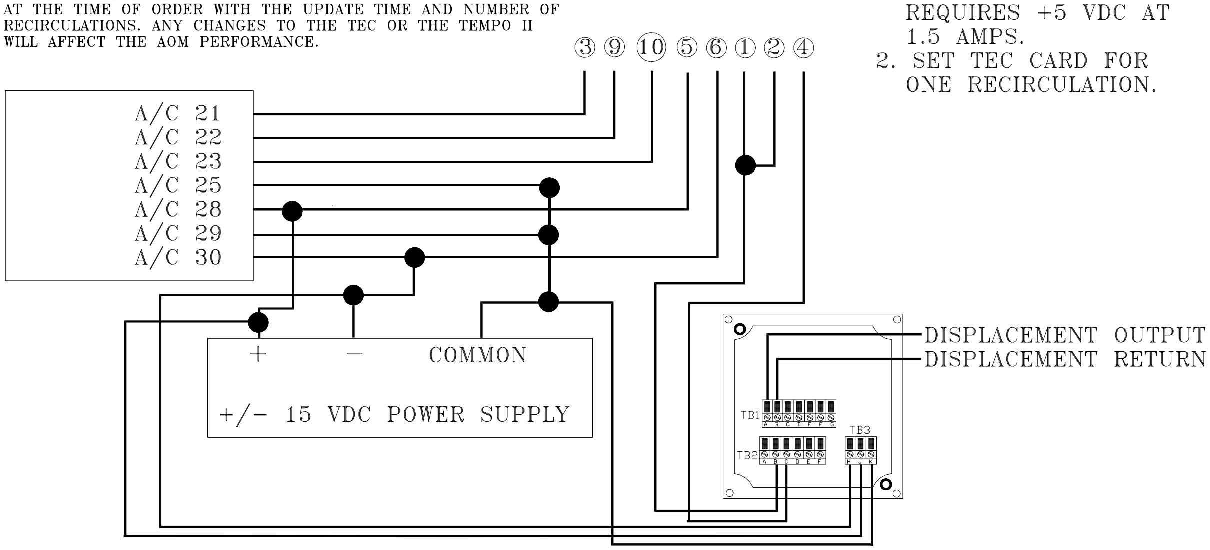
MTS® Sensors Division	A SIZE	DRAWING NUMBER APD-0013		DATE 1/27/95
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION A	ORIGINATOR DAVE BAKER	

WIRING GUIDE FOR A TEMPO II WITH A DPM (EXTERNAL INTERROGATION) TO WORK IN CONJUNCTION WITH AN AOM AND AN ALLEN BRADLEY CREONICS TEC CARD.



THE TEMPO II MUST BE CONFIGURED FOR A DPM WITH EXTERNAL INTERROGATION. RECIRCULATION MUST BE SET ACCORDING TO THE UPDATE TIME, SEE THE TEC CHART. THE AOM MUST BE SPECIFIED AT THE TIME OF ORDER WITH THE UPDATE TIME AND NUMBER OF RECIRCULATIONS. ANY CHANGES TO THE TEC OR THE TEMPO II WILL AFFECT THE AOM PERFORMANCE.

NOTES:
1. CREONICS TEC CARD REQUIRES +5 VDC AT 1.5 AMPS.
2. SET TEC CARD FOR ONE RECIRCULATION.

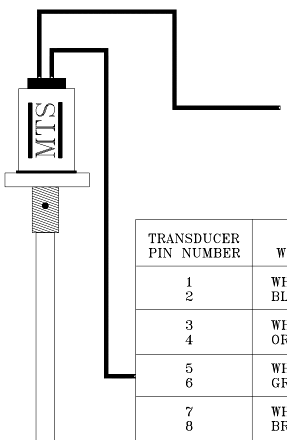


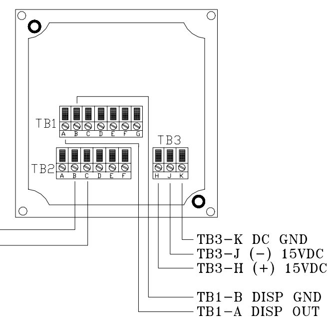
MTS Sensors Division ®	A SIZE	DRAWING NUMBER APD−0014	DATE 03/22/95
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION A	ORIGINATOR DAVE BAKER

ANALOG/DIGITAL SYSTEM CONFIGURATION WITH TEMPOSONICS II TRANSDUCER

THE SYSTEM CONFIGURATION ILLUSTRATED BELOW TYPICALLY SUPPLIES A DIGITAL DISPLACEMENT OUTPUT AND AN ANALOG VELOCITY OUTPUT, BUT AN ANALOG DISPLACEMENT OUTPUT IS AVAILABLE. SYSTEN COMPONENTS REQUIRED ARE THE TRANSDUCER WITH BUILT IN DIGITAL PERSONALITY MODULE (DPM), TDC CONTROLLER, AND AN ANOLOG OUTPUT MODULE (AOM).

TEMPOSONICS II CONNECTIONS TO ANALOG OUTPUT MODULE (AOM) WITH STRAIN RELIEF CONNECTORS





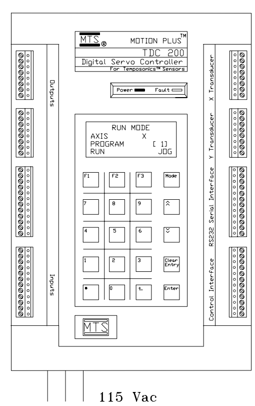
FROM TEMPOSONICS II

PIN 1 (WHITE/BLUE STRIPE) OR SOLID WHITE (DC GROUND)
PIN 4 (ORANGE/WHITE STRIPE) OR SOILD PINK (+ GATE)

CONNECTIONS TO TDC CONTROLLER

TRANSDUCER PIN NUMBER	STRIPED WIRE COLOR	SOLID WIRE COLOR	FUNCTIONAL DESCRIPTION	CONNECTION TO TDC
1 2	WHITE/BLUE STRIPE BLUE/WHITE STRIPE	WHITE BROWN	DC GROUND FRAME	TEMPO GND TEMPO GND
3 4	WHITE/ORANGE STRIPE ORANGE/WHITE STRIPE	GRAY PINK	(-) GATE (+) GATE	(-) GATE (+) GATE
5 6	WHITE/GREEN STRIPE GREEN/WHITE STRIPE	RED BLUE	VCC VEE	(+) 15 VDC (-) 15 VDC
7 8	WHITE/BROWN STRIPE BROWN/WHITE STRIPE	BLACK VIOLET	NO/CONN NO/CONN	NO/CONN NO/CONN
9 10	WHITE/GRAY STRIPE GRAY/WHITE STRIPE	YELLOW GREEN	(+) INTERR (-) INTERR	(+) INTERR (-) INTERR

TDC CONTROLLER



115 Vac

NOTE:

1. THE (+) GATE OUTPUT FROM THE TRANSDUCER MUST BE TERMINATED IN TWO LOCATIONS, AOM (TERMINAL BLOCK TB2-C) AND THE OTHER GOES TO THE TDC (+) GATE X OR Y TERMINAL STRIP.
2. CIRCUIT OR "REFERENCE" GROUND IS ESTABLISHED BY CONNECTING THE POWER SUPPLY COMMON(S) TO EARTH GROUND

MTS® Sensors Division	A SIZE	DRAWING NUMBER APD-0015		DATE 03/10/95
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION A	ORIGINATOR DAVE BAKER	

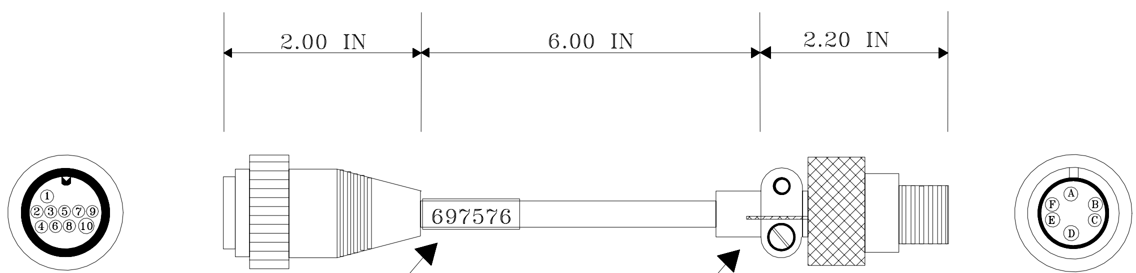
COMPANY: HUSKY PART # 697576

SUBJECT: TEMPOSONICS II REPLACEMENT CABLE
RETROFITTING THE SRH NEMA 4
ENCLOSURE

REF: RETROFIT CABLE FOR AOM'S
12 INCHES OR LESS

PIN/CONDUCTOR ASSIGNMENTS

WIRE PAIRS	FROM P1	NEUTER	TO P2
WHITE	1	GROUND	B
BROWN	2	FRAME	NOTE
GRAY	3	N/C	N/C
PINK	4	N/C	N/C
RED	5	VCC	F
BLUE	6	VEE	D
BLACK	7	RET GND	B
VIOLET	8	RET OUT	C
YELLOW	9	+ INT	B
GREEN	10	− INT	G



MOLDED

ID label constructed of embossing tape (approx. 1.25") and heat shrink (approx. 2")

DRAIN WIRE TWISTED WITH BROWN WIRE MAKING CONTACT TO THE ID OF THE CABLE CLAMP.

MS3101A14S-6P
(370018)

NOTE: TWIST THE SHIELD (DRAIN) WIRE AND THE FRAME WIRE TOGETHER (THIS TWISTED PAIR MUST BE BETWEEN THE CABLE CLAMP AND THE BOOT AND NOT TERMINATED)

OBSOLETE - SUPERCEEDED BY MPDC-0037

M.PUTNAM 7/23/96

Rev. B: Added Husky part # to cable, BKT, 5/7/96

MTS® Sensors Division	A SIZE	DRAWING NUMBER APD-0016		
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION B	ORIGINATOR DAVE BAKER	3/13/95

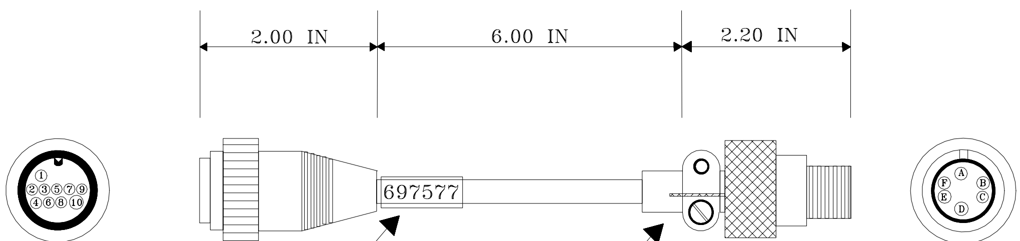
COMPANY: HUSKY PART # 697577

SUBJECT: TEMPOSONICS II REPLACEMENT CABLE
RETROFITTING THE SRH NEMA 4
ENCLOSURE

REF: RETROFIT CABLE FOR AOM'S
GREATER THAT 12 INCHES

PIN/CONDUCTOR ASSIGNMENTS

WIRE PAIRS	FROM P1	NEUTER	TO P2
WHITE	1	GROUND	B
BROWN	2	FRAME	NOTE
GRAY	3	N/C	N/C
PINK	4	N/C	N/C
RED	5	VCC	F
BLUE	6	VEE	D
BLACK	7	RET GND	B
VIOLET	8	RET OUT	C
YELLOW	9	+ INT	E
GREEN	10	- INT	B



ID label constructed of embossing tape (approx. 1.25") and heat shrink (approx.2")

MOLDED

DRAIN WIRE TWISTED WITH BROWN WIRE MAKING CONTACT TO THE ID OF THE CABLE CLAMP.

MS3101A14S-6P
(370018)

OBSOLETE - SUPERCEEDED BY MPDC-0038

M.PUTNAM 7/23/96

NOTE: TWIST THE SHIELD (DRAIN) WIRE AND THE FRAME WIRE TOGETHER (THIS TWISTED PAIR MUST BE BETWEEN THE CABLE CLAMP AND THE BOOT AND NOT TERMINATED)

Rev. B: Added Husky part # to cable, BKT, 5/7/96

MTS® Sensors Division	A SIZE	DRAWING NUMBER	APD-0017	
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION B	ORIGINATOR DAVE BAKER	3/13/95

SUBJECT: PLUG-IN ANALOG OUTPUT CARD WITH LP TRANSDUCER

THE ANALOG OUTPUT CARD IS A PLUG-IN TYPE CARD WHICH IS A DIRECT REPLACEMENT FOR THE "OLD STYLE" ELECTRONICS CARD. IT HAS ALL OF THE FEATURES OF THE ANALOG OUTPUT MODULE (AOM) WITH THE ADDED BENIFIT OF BEING ABLE TO BE RETROFITTED PHYSICALLY AND FUNCTIONALLY IN PLACE OF THE OLD STYLE CARD.

OUTPUTS AVAILABLE:

0 TO +10 VDC	(FORWARD & REVERSE ACTING)
0 TO −10 VDC	(FORWARD & REVERSE ACTING)
−10 TO +10 VDC	(FORWARD & REVERSE ACTING)

FROM LP TRANSDUCER	WIRE COLOR	TO AOM PLUG-IN CARD CONNECTIONS
PIN 1	BLUE	N/C
PIN 2	GREEN	PIN 14
PIN 3	YELLOW	PIN 7
PIN 4	ORANGE	PIN 15
PIN 5	RED	PIN 5
PIN 6	BLACK	PIN 1

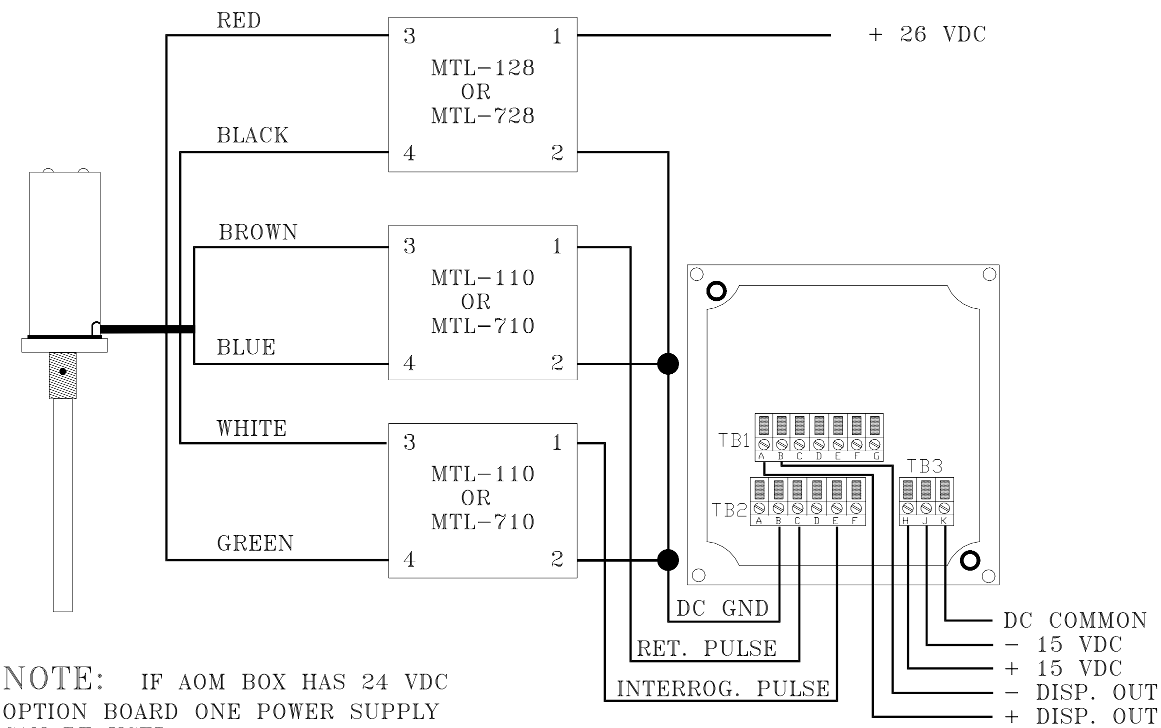
PIN #

1 DC GROUND/(CURR./RET. FOR GND. SYSTEMS
2 + 5 VDC INPUT/OPTIONAL
3 − 15 VDC INPUT
4 + 12 VDC TO LDT
5 + 15 VDC INPUT/(+ 24 VDC OPTIONAL)
6 + 15 VDC INPUT TO LDT
7 − INTERROGATION PULSE TO LDT
8 − 15 VDC TO TRANSDUCER
9 + PWM/OPTIONAL
10 VELOCITY CURR./RET. (UNGND)[OPTIONAL]
11 ANALOG VELOCITY OUTPUT/OPTIONAL
12 ANALOG DISPLACE. OUTPUT/(CURR. SOURCE)
13 (OPTIONAL CURR. RET. FOR UNGND. SYSTEM)
14 RETURN PULSE FROM TRANSDUCER
15 + INTERROGATION PULSE TO TRANSDUCER

NOTE: SHIELD WIRE (DRAIN) CAN BE CONNECTED TO PIN #1 ON THE AOM CARD.

MTS® Sensors Division	A SIZE	DRAWING NUMBER APD-0018	DATE 4/24/95
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION A	ORIGINATOR DAVE BAKER

FOR INTRINSICALLY SAFE SYSTEMS

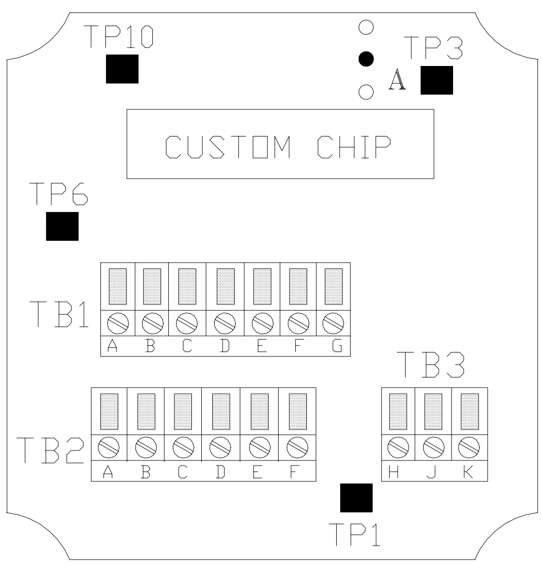


NOTE: IF AOM BOX HAS 24 VDC OPTION BOARD ONE POWER SUPPLY CAN BE USED.

MTS® Sensors Division	A SIZE	DRAWING NUMBER APD-0019	DATE 4/25/95
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION A	ORIGINATOR DAVE BAKER

AOM BOXES JUMPER TO CHANGE (+,−) INTERROGATION

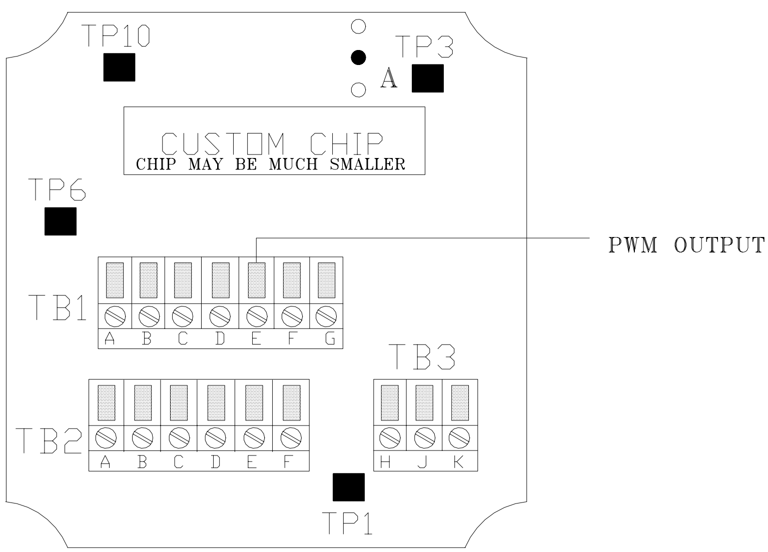
1. A JUMPER FROM THE CENTER HOLE TO THE EDGE OF THE BOARD IS (−) INTERROGATION.
2. A JUMPER FROM THE CENTER HOLE TO THE CUSTOM CHIP IS (+) INTERROGATION.



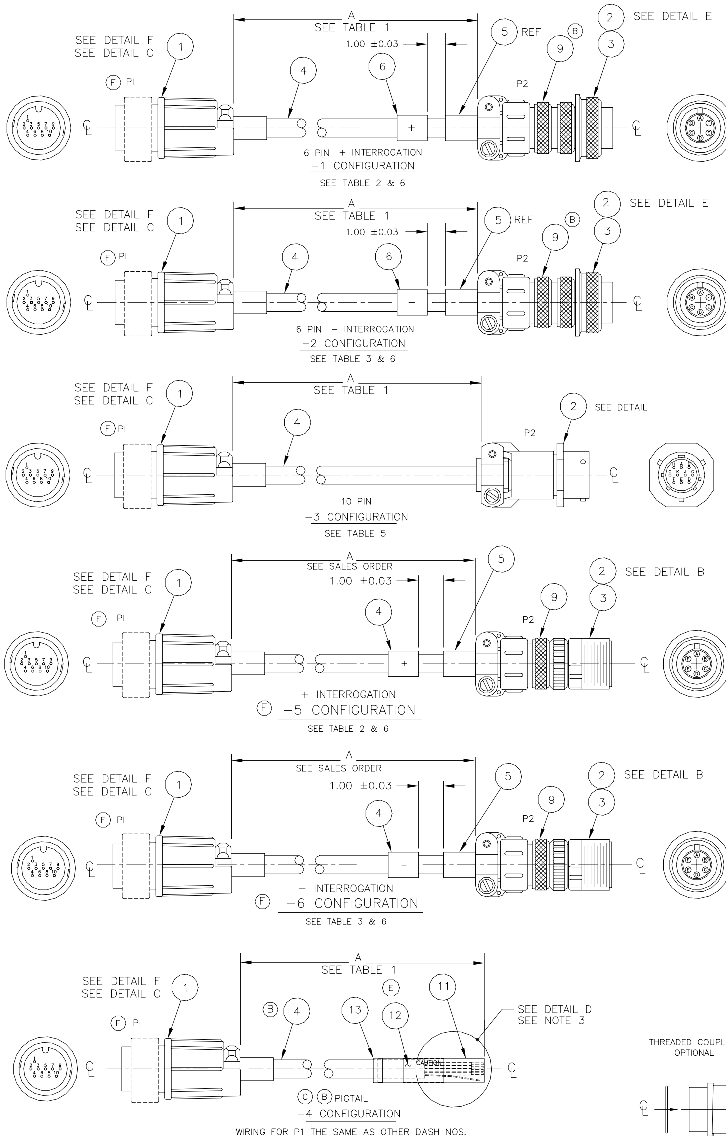
MTS® Sensors Division	A SIZE	DRAWING NUMBER APD−0020		DATE 5/19/95
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION A	ORIGINATOR DAVE BAKER	

AOM BOXES MANUFACTURED FOR MOOG CONTROLS

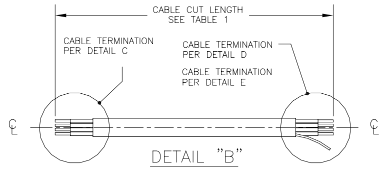
1. ALL MOOG CONTROL AOM BOXES & BOARDS TO HAVE PWM OUTPUT
2. ALL MOOG CONTROL AOM BOXES & BOARDS TO BE CONFORMALALLY COATED



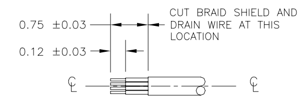
MTS® Sensors Division	A SIZE	DRAWING NUMBER APD-0021	DATE 04/21/96
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION A	ORIGINATOR BRIAN THOMPSON



NOTE:
1. TOLERANCE FOR DIMENSION A = $^{+1.00}_{-0.50}$ IN
2. SOLDER ALL 6 JUNCTION WIRES TOGETHER AT THIS LOCATION.
3. LOCATE ITEM 11 (ANTI-STATIC BAG) SO CABLE BOTTOMS OUT IN BOTTOM OF BAG.

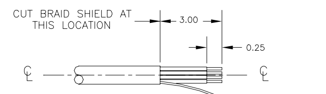


DETAIL "B"



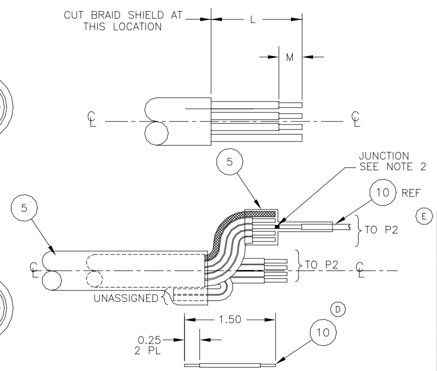
DETAIL "C"

STRIPPING FOR -1 TO -4 CONFIGURATIONS



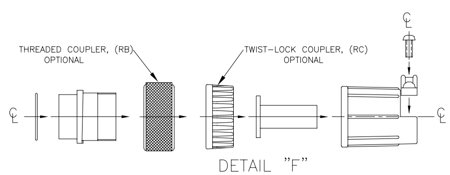
DETAIL "D"

STRIPPING FOR -4 CONFIGURATION



DETAIL "E"

STRIPPING AND DRESSING FOR -1 AND -2 CONFIGURATIONS



DETAIL "F"

FOR ASSEMBLY DETAIL OF ITEM 1
SEE MTS DOCUMENT 400755-3
FOR COMPLETE CABLE TERMINATIONS
SEE DETAIL J AND TABLES 2 TO 5

TABLE 1

LENGTH DEFINITIONS

DASH NO.	CABLE STYLE	INTERROGATION	CABLE CUT LENGTH $^{+1.00}_{-0.50}$ SEE DETAIL B	LENGTH A
1	6 PIN	POSITIVE	LENGTH SPECIFIED ON SALES ORDER + 3.00 INCHES	LENGTH SPECIFIED ON SALES ORDER
2	6 PIN	NEGATIVE	LENGTH SPECIFIED ON SALES ORDER + 3.00 INCHES	LENGTH SPECIFIED ON SALES ORDER
3	10 PIN	–	LENGTH SPECIFIED ON SALES ORDER + 3.00 INCHES	LENGTH SPECIFIED ON SALES ORDER
4	PIGTAIL	–	LENGTH SPECIFIED ON SALES ORDER + 6.00 INCHES	LENGTH SPECIFIED ON SALES ORDER
5	6 PIN MALE	POSITIVE	LENGTH SPECIFIED ON SALES ORDER + 6.00 INCHES	LENGTH SPECIFIED ON SALES ORDER
6	6 PIN MALE	NEGATIVE	LENGTH SPECIFIED ON SALES ORDER + 6.00 INCHES	LENGTH SPECIFIED ON SALES ORDER

TABLE (B) 2 = R1 = C1

-1 CONFIGURATION, 6 PIN POSITIVE INTERROGATION (AOM/DIB RETROFIT WIRING)

WIRE PAIRS & WIRES	FROM	TO	DIMENSIONS FOR DETAIL "E" L ±0.06	M ±0.03	WAVEGUIDE DRV/AMP BD (P1)
WHITE	P1-1	JUNCTION	1.00	0.25	GND
BROWN	P1-2	JUNCTION	1.00	0.25	FRAME
GRAY	P1-3	UNASSIGNED	1.00	–	–
PINK	P1-4	UNASSIGNED	1.00	–	–
RED	P1-5	P2-F	1.00	0.25	** VCC, +12V
BLUE	P1-6	P2-D	1.00	0.25	** VEE, -15V
BLACK	P1-7	JUNCTION	1.00	0.25	AMP RETURN
VIOLET	P1-8	P2-C	1.00	0.25	AMP OUTPUT
YELLOW	P1-9	P2-E	1.00	0.25	+ INTRG.
GREEN	P1-10	JUNCTION	1.00	0.25	- INTRG.
–	–	A	–	–	–
	–		–	–	–
DRAIN WIRE (SHIELD WIRE)	–	JUNCTION	1.00	–	–
ITEM 10 (1.50" LONG WIRE)	JUNCTION	P2-B	–	–	–

NOTE: ** FOR WIRING OF NON-RETROFIT CABLES THE POWER SUPPLY VOLTAGES ARE NOMINALLY ±12V TO ±15V.

T(B)BLE 3 = R2 = C2

-2 CONFIGURATION, 6 PIN NEGATIVE INTERROGATION (AOM/DIB RETROFIT WIRING)

WIRE PAIRS & WIRES	FROM	TO	DIMENSIONS FOR DETAIL "E" L ±0.06	M ±0.03	WAVEGUIDE DRV/AMP BD (P1)
WHITE	P1-1	JUNCTION	1.00	0.25	GND
BROWN	P1-2	JUNCTION	1.00	0.25	FRAME
GRAY	P1-3	UNASSIGNED	1.00	–	–
PINK	P1-4	UNASSIGNED	1.00	–	–
RED	P1-5	P2-F	1.00	0.25	** VCC, +12V *
BLUE	P1-6	P2-D	1.00	0.25	** VEE, -15V *
BLACK	P1-7	JUNCTION	1.00	0.25	AMP RETURN
VIOLET	P1-8	P2-C	1.00	0.25	AMP OUTPUT
YELLOW	P1-9	JUNCTION	1.00	0.25	+ INTRG.
GREEN	P1-10	P2-E	1.00	0.25	- INTRG.
–	–	A	–	–	–
	–		–	–	–
DRAIN WIRE (SHIELD WIRE)	–	JUNCTION	1.00	–	–
ITEM 10 (1.50" LONG WIRE)	JUNCTION	P2-B	–	–	–

NOTE: ** FOR WIRING OF NON-RETROFIT CABLES THE POWER SUPPLY VOLTAGES ARE NOMINALLY ±12V TO ±15V.

TABLE 4 = R0 = P0

(E)

-4 CONFIGURATION
PIGTAIL WIRING

WIRE PAIRS	FROM P1	WAVEGUIDE DRV/AMP BD (P1)	TO PIGTAIL
WHITE	1	GND	
BROWN	2	FRAME	
GRAY	3	- GATE OUT	
PINK	4	+ GATE OUT	
RED	5	VCC, +15V	
BLUE	6	VEE, -15V	
BLACK	7	AMP RETURN	
VIOLET	8	AMP OUTPUT	
YELLOW	9	+ INTRG.	
GREEN	10	- INTRG.	
DRAIN WIRE (SHIELD WIRE)	–	–	

TABLE 5 = R3 = C3

10 PIN
-3 CABLE CONFIGURATIONS

WIRE PAIRS	FROM P1	TO P2	WAVEGUIDE DRV/AMP BD (P1)	DPM/RPM (EXT. MODE) (P2)	DPM (INT. MODE) (P2)	NPM (EXT. MODE) (P2)
WHITE	1	A	GND	GND	GND	GND
BROWN	2	J	FRAME	EARTH	EARTH	EARTH
GRAY	3	K	- GATE OUT	- GATE OUT	- GATE OUT	–
PINK	4	G	+ GATE OUT	+ GATE OUT	+ GATE OUT	–
RED	5	H	VCC, +15V	VCC, +15V	VCC, +15V	VCC, +15V
BLUE	6	B	VEE, -15V	VEE, -15V	VEE, -15V	VEE, -15V
BLACK	7	A	AMP RETURN	–	–	AMP RET (GND)
VIOLET	8	F	AMP OUTPUT	–	–	AMP OUTPUT
YELLOW	9	E	+ INTRG.	+ INTRG.	–	* + INTRG.
GREEN	10	D	- INTRG.	- INTRG.	–	* - INTRG.
DRAIN WIRE (SHIELD WIRE)	–	J	–	EARTH	EARTH	EARTH

* UNDER NO CONDITION WILL + AND - INTERROGATION BE CONNECTED AT THE SAME TIME.
THE UNUSED INTERROGATION LEAD MUST BE CONNECTED TO DC GROUND.

TABLE 6

6 PIN
-1, -2, -5, -6 CABLE CONFIGURATIONS

WIRE PAIRS	FROM P1	TO P2	WAVEGUIDE DRV/AMP BD (P1)	APM (INT. MODE) (P2)	NPM (EXT. MODE) (P2)
WHITE	1	B	GND	GND	GND
BROWN	2	B	FRAME	EARTH	EARTH
GRAY	3	B	- GATE OUT	DISPL. RET. GND	–
PINK	4	A	+ GATE OUT	DISPL. OUT	–
RED	5	F	VCC, +15V	VCC, +15V	VCC, +15V
BLUE	6	D	VEE, -15V	VEE, -15V	VEE, -15V
BLACK	7	–	AMP RETURN	–	–
VIOLET	8	–	AMP OUTPUT	–	–
YELLOW	9	E	+ INTRG.	–	* + INTRG.
GREEN	10	E	- INTRG.	–	* - INTRG.
DRAIN WIRE (SHIELD WIRE)	–		–	EARTH	EARTH

* UNDER NO CONDITION WILL + AND - INTERROGATION BE CONNECTED AT THE SAME TIME.
THE UNUSED INTERROGATION LEAD MUST BE CONNECTED TO DC GROUND.

REV	DATE	BY	DESCRIPTION
A	8/13/96	BKT	ABSORBED 250733 INTO APD SYSTEM

REVISIONS

MATERIAL ———	DRAWN CW/JS	DATE 5-31-90	MTS SENSORS DIVISION RESEARCH TRIANGLE PARK, NORTH CAROLINA 27709
	CHK	DATE	
FINISH ———	ENGR	DATE	TITLE INTEGRAL CABLES & EXTENSION CABLES
	QC	DATE	
	MFG	DATE	
DO NOT SCALE DRAWING	SCALE ———	SHEET 1 OF 1	DWG NO. APD-0022 REV A

Cross Reff. AP1-0001

GUIDE TO COMMON CONNECTORS

370015 AMPHENOL 6 PIN FEMALE PLUG MS3106A-14S-6S

USED FOR CONNTECTING TEMPO II TO AOM OR DIB BOXES.
R1 & C1 FOR + INTERROGATION PULSES
R2 & C2 FOR - INTERROGATION PULSES
MATES WITH 37014 BOX MOUNTED CONNECTOR (MS3102A-14S-6P).

370017 AMPHENOL 5 PIN FEMALE PLUG MS3106A-14S-5S

MATES WITH AOM BOX J1 MS CONNECTOR (MS3101E-14S-5P).

370011 AMPHENOL 6 PIN FEMALE ENVIRONMENTAL CONNECTOR MS3106E-14S-6S

MATES TO TEMPO I HEAD CONNECTOR OF STYLE 02 SRH AND RUGGEDIZED STYLES RATED NEMA 4. USED FOR FIELD FABRICATION OF EXTENTION CABLES WHEN ORDERED WITH BOX OR MATCHING MODULE CONNECTOR. ALSO SEE EXPLANATION FOR 370018. ALSO USED AS AN ENVIRONMENTAL VERSION OF 370015. PART# 370062 (MS3116F-10-6S) IS AN ENVIRONMENTAL TWIST-LOCK VERSION OF THIS CONNECTOR.

370018 AMPHENOL 6 PIN MALE CABLE CONNECTOR MS3101A-14S-6P

USED FOR FIELD CABLE EXTENSION FROM TEMPO I NEMA 4 SRH TRANSDUCERS OR THEIR TEMPO II RETROFITS. MATES WITH 370011 CONNECTOR. MUST BE WIRED FOR POSITIVE (R4 & C4) INTERROGATION PULSE OR NEGATIVE (R5 & C5) INTERROGATION PULSE. PART# 370090 (MS3101E-14S-6P) IS AN ENVIRONMENTAL VERSION OF THIS CONNECTOR.

370010 AMPHENOL 5 PIN FEMALE ENVIRONMENTAL CONNECTOR MS3106E-14S-5S

MATES WITH AOM BOX J1 MS CONNECTOR. USED AS AN ENVIRONMENTAL SUBSTITUTE FOR 370017.

370013 AMPHENOL 10 PIN FEMALE CABLE CONNECTOR MS3116F-12-10S

MATES WITH DIB J1 CONNECTOR OR WITH 370160 TO BYPASS DIB OR AOM BOX. SEE 370160.

370160 AMPHENOL 10 PIN ENVIRONMENTAL MALE MS CONNECTOR MS3111F-12-10P

USED MOST COMMONLY FOR TEMPO II'S WITH PERSONALITY MODULES (R3 & C3). MATES WITH 370013 TO BYPASS A DIB BOX WHEN INSTALLING A TEMPO IIWITH PERSONALITY MODULE.

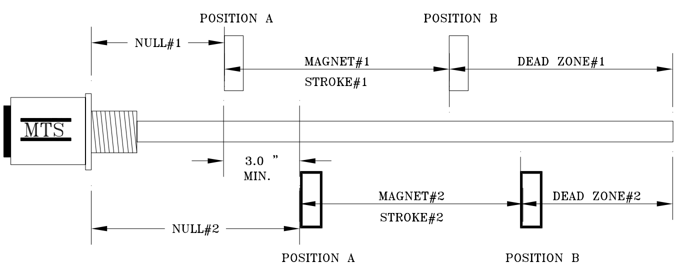
400755-3 CONNECTOR KIT FOR FABRICATING CABLES THAT MATE DIRECTLY WITH AN RB OR RC TRANSDUCER HEAD CONNECTOR. THIS IS NOT A MS CONNECTOR. IT IS SPECIFICALLY FOR THE TEMPO II AND LH HEAD

251135 MATING CONNECTOR FOR USE WITH LP TRANSDUCER

MTS® SENSORS DIVISION	A SIZE	DRAWING NUMBER APD-0023	DATE 9/22/97
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION B	ORIGINATOR DDB

Cross Reff. AP1-0002

DUAL CHANNEL SYSTEM



MAGNET #1

1) ______ NULL ______ STROKE ______ DEAD ZONE = ______ ROD LENGTH

2) OUTPUT = ______ POSITION A TO ______ POSITION B VDC

MAGNET #2

1) ______ NULL ______ STROKE ______ DEAD ZONE = ______ ROD LENGTH

2) OUTPUT = ______ POSITION A TO ______ POSITION B VDC

LIMITS:

DEAD ZONE #2 SHOULD BE A MINIMUM OF 3 INCHES GREATER THAN DEAD ZONE #1.
OUTPUT LIMITS ARE -10 VDC TO +10 VDC.
MINIMUM OF 2.5 INCH DEAD ZONE REQUIRED FOR DEAD ZONE #2.

NOTES:

A) STROKE #1 MAY OR MAY NOT OVERLAP STROKE #2. IF NOT, THEN A 3" GAP IS NEEDED
B) MAGNET #1 AND MAGNET #2 MUST NEVER BE CLOSER THAN 3" APART.
C) MAXIMUM ROD LENGTH IS 300 INCHES.

Rev. B: Voltage output only.

MTS® SENSORS DIVISION	A SIZE	DRAWING NUMBER APD-0024	DATE 9/22/97
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION C	ORIGINATOR DDB

Cross Reff. AP1-0003
DRAWING NO: AP1-0005
ORIGINATOR DDB

APPLICATION NOTE

MTS SENSORS DIVISION 3001 SHELDON DR. CARY, NORTH CAROLINA 27513

SUBJECT: CONVERSION FROM OLD TCS COUNTER CARD TO NEW MK-292 CARD.

OLD TSC CARD

POWER SUPPLY REQUIREMENTS:
+\- 15 VDC FOR TRANSDUCER
+ 5 VDC FOR OUTPUTS ON CARD

UNIT IS SCALED AT FACTORY FOR STROKE LENGTH,RESOLUTION AND MEASURING DIRECTION.

UNIT USES PULSE WIDTH MODULATION INPUT FROM TRANSDUCER IS SET TO INTERNAL INTERROGATION.

UNIT IS BUILT AT FACTORY FOR A BINARY OR BCD OUTPUT.

UNITS ARE BUILT AS SYSTEMS AND CANNOT BE SUBSTITUTED IN ANY WAY.

NEW MK-292 CARD

POWER SUPPLY REQUIREMENTS
+ 24 VDC FOR CARD AND TRANSDUCER
+ 5 TO 24 VDC FOR ADJUSTIBLE OUTPUTS

THE INPUT LEVEL APPLIED DETERMINES THE OUTPUT LEVEL (EXAMPLE: AN INPUT OF 5 VDC, YOU WILL RECIVE A 5 VDC TTL LEVEL OUTPUT).

THE CUSTOMER PROGRAMS THE UNIT FOR SPECIFIC STROKE LENGTH,RESOLUTION AND MEASURING DIRECTION.

UNIT CAN USE EITHER A START/STOP OR PULSE WIDTH MODULATION SET TO EXTERNAL INTERROGATION ONLY.

WIRING BY THE CUSTOMER DETERMINES THE OUTPUTS OF BINARY, BDC OR GRAY CODE.

** WIRING FOR BOTH UNITS IS TOTALLY DIFFERENT

** MOUNTING ACCESSORIES AND HARDWARE ARE NOT DIRECTLY COMPATIBLE.

MTS® SENSORS DIVISION	A SIZE	DRAWING NUMBER APD-0025	DATE 9/22/97
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION B	ORIGINATOR DDB

Cross Reff. AP1-0004

DRAWING NO: A-2007 rev.B
ORIGINATOR: LLJ

APPLICATION NOTE

MTS SENSORS DIVISION 3001 SHELDON DR. CARY, NORTH CAROLINA 27513

Subject: ALLEN BRADLEY SERIES A, REVISION D 1771-QB
Ref: Linear (hydraulic) Positioning Module

The Allen-Bradley 1771-QB module is a dual-loop linear position controller designed to occupy one option slot in the Allen-Bradley 1771 Universal I/O chassis. The module is used to control and monitor a precise linear position of a tool or workpiece along one or two axes.

This module connects to a Temposonics? II feedback system comprising of a transducer with a Digital Personality Module (DPM) integrated into the head electronics to provide a feedback of the axes position, thereby making it a closed-loop system.

The module can work with electrical strokes up to 15 feet with a 2 thousandths of an inch resolution. Transducers with smaller strokes can achieve a more accurate resolution.

The module sends an interrogation signal every 2 milliseconds to a Temposonics? II transducer with a DPM option board programmed for external interrogation (synchronous operation).[1] The DPM generates a gate that is proportional to the displacement of the magnet along the stroke length of the transducer to the module. The maximum pulse width (gate)[2] returned by the DPM depends on the transducer stroke length and the number of circulations (1 to 10) programmed on the DPM. Increasing the circulations[3] will double the gate width and resolutions of the position reading. The maximum pulse width that can be measured by the module without overflowing its internal counter is approximately 1680 microseconds. The maximum stroke length the module can measure is 15 feet with a 2 thousandths of an inch resolution and 2 tenthousandths of an inch with strokes up to 20 inches. Use the equation below to determine the maximum transducer length for your system.

Maximum Transducer Length = 1680/ (T x N) - 3

T = Gradient (The time at which the sonic wave travels within the waveguide, typically 9.05 microseconds per inch). This number is stamped on the transducer label.

N = Number of circulations (1 to 10)

Number of circulations	Resolution (inches)	Max. Transducer Length (inches)
1	0.002	182.6
2	0.001	89.8
3	0.0006	58.8
4	0.0005	43.4
5	0.0004	34.1
6	0.0003	27.9
7	0.0003	23.5
8	0.0002	20.2
9	0.0002	17.6
10	0.0002	15.5

Example:

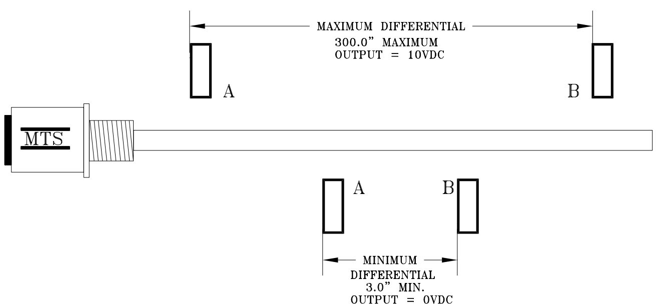
The last 5 digits for a Temposonics? II transducer with a built in DPM using a 14 inch transducer stroke with a ???????? ???????????????0.0002 inch resolution are: DE0010

1. External interrogation - A synchronous operation (customer generates the interrogation pulse to the DPM.)
2. Gate - Represents the time between the generation of an interrogation pulse and receiving the signal.
3. Circulations - A process that involves the re-triggering of an interrogation pulse a fixed number of times by the return pulse to improve resolution.

MTS® SENSORS DIVISION	A SIZE	DRAWING NUMBER APD-0026	DATE 9/22/97
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION B	ORIGINATOR DDB

Cross Reff. AP1-0005

DIFFERENTIAL OUTPUTS



Note 1. For TDU meter use Start/Stop out of transducer

THE SPECIFICATIONS WHEN ORDERING DIFFERENTIAL OPTION	LIMITS:
NULL SPACE IN INCHES	2.00"
DEAD SPACE IN INCHES	2.50" SET
MIN. DIFF. IN INCHES	3:00"
MAX. DIFF. IN INCHES	STROKE
OUTPUT RANGES (if using AOM) (VOLTAGE ONLY)	-10 TO +10VDC

NOTES:

1.) MINIMUM AND MAXIMUM DIFFERENTIAL CAN OCCUR ANYWHERE ALONG THE ACTIVE STROKE OF THE TRANSDUCER.

2.) MINIMUM AND MAXIMUM DIFFERENTIAL ARE ADJUSTABLE APPROXIMATELY 2%.

Rev B: Corrected spelling, added set to 2.5" dead space & note 1 & AOM to output

MTS® SENSORS DIVISION CARY, NORTH CAROLINA	A SIZE	DRAWING NUMBER APD-0027	DATE 9/23/97
	SHEET 1 OF 1	REVISION D	ORIGINATOR DDB

Cross Reff. AP1-0006

ORDERING PARAMETERS FOR ANALOG/ DIGITAL SYSTEMS

CHECK OFF DEVICE(S) BEING USED IN SYSTEM WITH AOM BOX.

DIB	
DPM	
CONTROLLER	

WHEN CONTROLLER IS USED IN SYSTEM, THE MAKE AND UPDATE TIME IS REQUIRED.

MAKE	
UPDATE TIME	

CIRCULATIONS ARE REQUIRED ON ALL SYSTEMS.

CIRCULATIONS	

ENCLOSURE STYLE IS REQUIRED ON ALL SYSTEMS.

31=STRAIN RELIEF	
32=5/6 PIN MS CONN	
35=PLUG-IN CARD	

NOTE: THE DIB OR DPM WILL ALWAYS BE IN EXTERNAL INTERROGATION MODE.

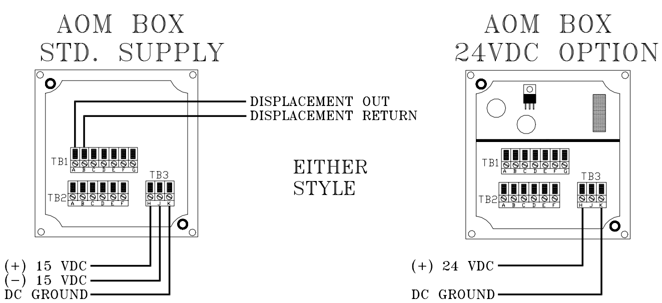
Rev. B: Add Enclosure Style, chg recirculation to circulation; BKT

MTS® SENSORS DIVISION CARY, NORTH CAROLINA	A SIZE	DRAWING NUMBER APD-0028	DATE 9/23/97
	SHEET 1 OF 1	REVISION C	ORIGINATOR DDB

Cross Reff. AP1-0007

WIRING OF LP TO AOM BOX

PIN NO#	WIRE COLOR	FUNCTION	TO AOM TERMINAL	TO AOM J2 6-PIN
1	BLUE	GATE (-)	N/C	N/C
2	GREEN	GATE (+)	TB2-C	C
3	YELLOW	INTERR (-)	TB1-G	E
4	ORANGE	INTERR (+)	TB2-E	D
5	RED	VCC (+)	TB3-H	A
6	BLACK	DC GND.	TB2-B	B
7	SHIELD	FRAME GND.	TB2-B	B



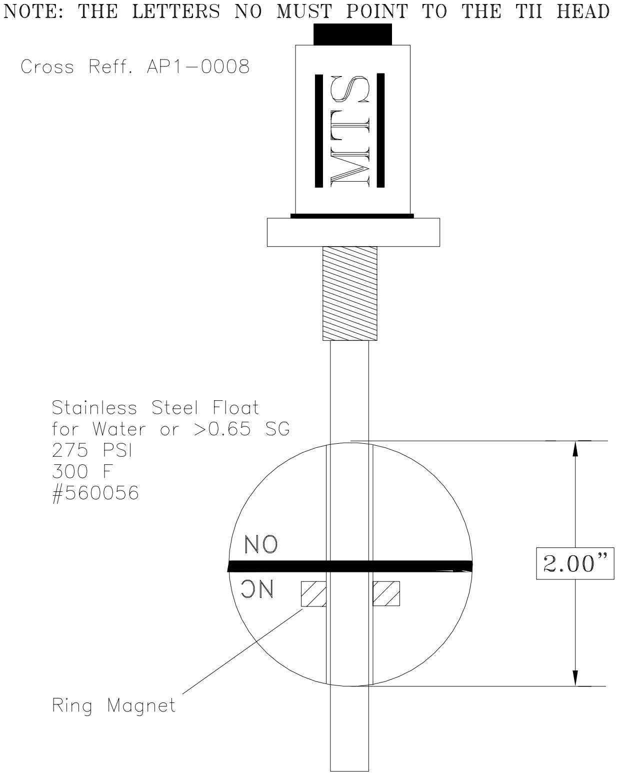
NOTES:

1. MAXIMUM LOAD ON 4/20 mA UNGROUNDED IS 400 OHMS.
2. MAXIMUM LOAD ON 4/20 mA GROUNDED IS 500 OHMS.
3. ON THE 4/20 mA GROUNDED THE SUPPLY GROUND IS USED AS THE RETURN. *DO NOT USE TB1-B AS YOUR RETURN*.
4. THE AOM (M/N) MUST REFLECT LP STROKE (31XXXXXXXLPXXXX).
5. THIS WIRING IS CORRECT AS OF 4/96.
6. A.O.M. NOT COMPATIBLE WITH SE BASED LP. SEE APPLICATIONS

REV B CHANGED VELOCITY RMP 3/25/96
REV C CORRECTED RED WIRE TO TB3-H BKT 4/30/96
REV D ADDED NOTE 6, AP1-0007 CHANGED TO APD-0029 TEP 9/23/97

MTS® SENSORS DIVISION CARY, NORTH CAROLINA	A SIZE	DRAWING NUMBER APD-0029	DATE 9/23/97
	SHEET 1 OF 1	REVISION D	ORIGINATOR DDB

NOTE: THE LETTERS NO MUST POINT TO THE TII HEAD

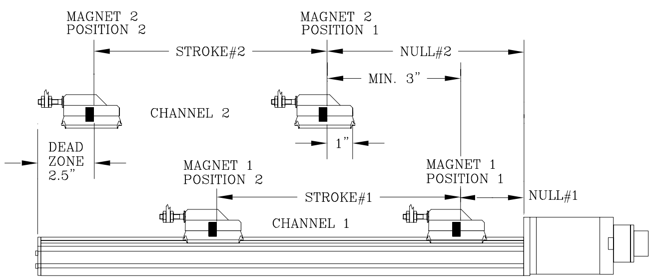


Rev. B: Add magnet & dimension, remove nylock; BKT

MTS® SENSORS DIVISION	A SIZE	DRAWING NUMBER APD-0030	DATE 9/23/97
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION C	ORIGINATOR BKT

DUAL CHANNEL SYSTEM
FOR
TEMPO III PA CAPTIVE SLIDE

Cross Reff. AP1-0009



CHANNEL 1
MAGNET #1

1. _________ IN. (NULL #1) __________ IN. (STROKE #1)

2. OUTPUT = __________ (POSITION 1) TO __________ (POSITION 2) VDC OR mA

CHANNEL 2
MAGNET #2

1. _________ IN. (NULL #2) __________ IN. (STROKE #2)

2. OUTPUT = __________ (POSITION 1) TO __________ (POSITION 2) VDC OR mA

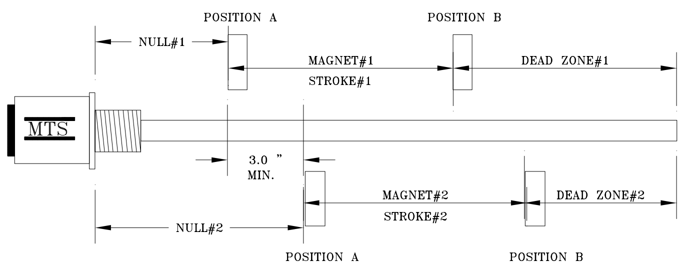
LIMITATIONS:
1. A minimum of 3 inches of spacing must be mainained between magnets.
2. Output limits are 0 to 10 VDC, reverse acting, 4 to 20 mA grounded, reverse acting, 0 to 20 mA grounded, reverse acting.
3. Both outputs must be of common typy, either VDC or mA.

MTS® SENSORS DIVISION CARY, NORTH CAROLINA	A SIZE	DRAWING NUMBER APD-0031	DATE 9/23/97
	SHEET 1 OF 1	REVISION C	ORIGINATOR RSM

Cross Reff. AP1-0010

DUAL CHANNEL SYSTEM

TEMPO III RH ROD STYLE



MAGNET #1

1) ______ ______ ______ = ______
NULL STROKE DEAD ZONE ROD LENGTH

2) OUTPUT = ______ TO ______ VDC OR mA
POSITION A POSITION B

MAGNET #2

1) ______ ______ ______ = ______
NULL STROKE DEAD ZONE ROD LENGTH

2) OUTPUT = ______ TO ______ VDC OR mA
POSITION A POSITION B

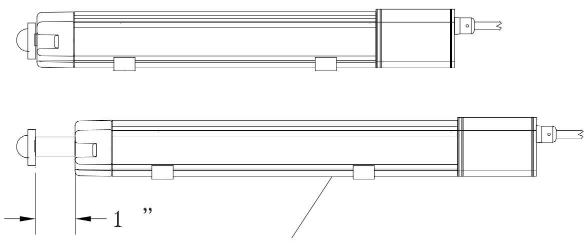
LIMITATIONS:

1. A MINIMUM OF 3 INCHES OF SPACING MUST BE MAINAINED BETWEEN MAGNETS
2. NULL MUST BE GREATER THAN 2 INCHES
3. OUTPUT LIMITS ARE 0 TO 10VDC, REVERSE ACTING, 4 TO 20mA, REVERSE ACTING, 0 TO 20mA, REVERSE ACTING.
4. BOTH OUTPUTS MUST BE COMMON, EITHER VDC OR mA.
5. ROD LENGTHS SHOULD BE EQUAL

MTS® SENSORS DIVISION CARY, NORTH CAROLINA	A SIZE	DRAWING NUMBER APD-0032	DATE 09/23/97
	SHEET 1 OF 1	REVISION D	ORIGINATOR RSM

Cross Reff. AP1-0011

RETROFITING NEW SE BASED LP



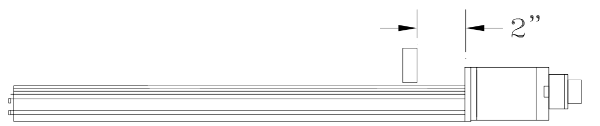
INCREASE STROKE BY ONE INCH

DUE TO THE MECHANICAL DIFFERENCES IN THE SE BASED LP AND THE EARLIER VERSION LP, THE BLANKING PULSE IS NOT COMPATABLE WITH THE TDU, AOM AND MK292.
A SOLUTION TO THIS PROBLEM IS TO INCREASE THE STROKE LENGTH OF THE LP BY ONE INCH AND SLIDE THE LP BODY BACK ONE INCH. THIS WILL EFFECTIVLY DUPLICATE THE BLANKING OF THE OLD LP AND ALLOW THE SYSTEM TO WORK PROPERLY

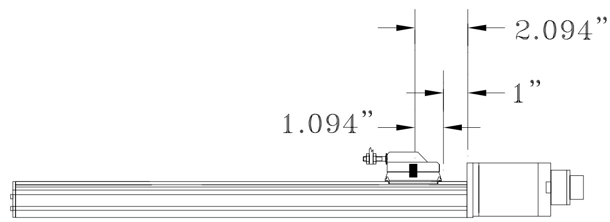
MTS® SENSORS DIVISION CARY, NORTH CAROLINA	A SIZE	DRAWING NUMBER APD-0033	DATE 9/23/97
	SHEET 1 OF 1	REVISION B	ORIGINATOR RSM

Cross Reff. Ap1-0012

RETROFIT OF LA SE BASED SENSORS



FLOATING MAGNET



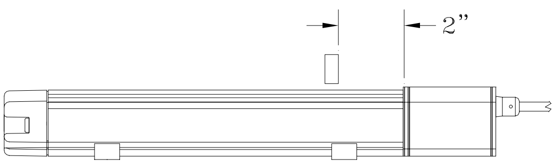
CAPTIVE SLIDE

WHEN USING THE LA STYLE TRANSDUCERS, WITH A TDU, MK292 AND AOM IT IS NECESSARY TO INCREASE THE STROKE LENGTH BY ONE INCH AND START THE NULL POSITION ONE INCH OUT. THIS COMPENSATES FOR THE DIFFERENCE IN BLANKING RANGE BETWEEN THE OLD SENSORS AND THE SE BASED SENSORS.

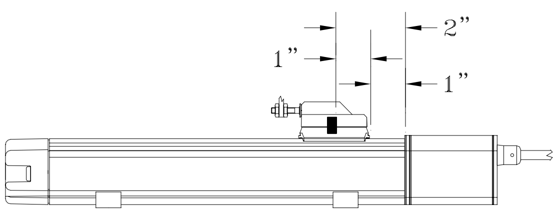
MTS® SENSORS DIVISION CARY, NORTH CAROLINA	A SIZE	DRAWING NUMBER APD-0034	DATE 9/23/97
	SHEET 1 OF 1	REVISION B	ORIGINATOR RSM

Cross Reff. AP1-0013

RETROFIT OF LP SE BASED SENSORS



FLOATING MAGNET

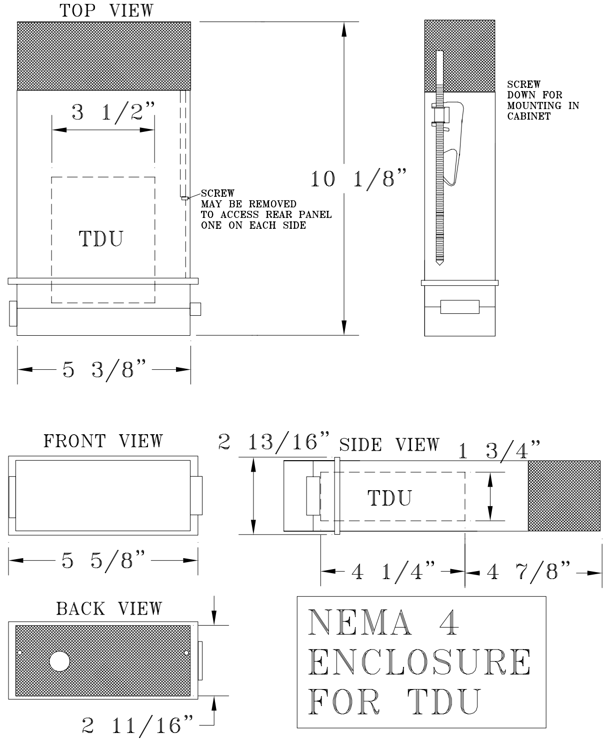


CAPTIVE SLIDE

WHEN USING THE LP SE BASED TRANSDUCERS, WITH A TDU, MK292 AND AOM IT IS NECESSARY TO INCREASE THE STROKE LENGTH BY ONE INCH AND START THE NULL POSITION ONE INCH OUT. THIS COMPENSATES FOR THE DIFFERENCE IN BLANKING RANGE BETWEEN THE OLD SENSORS AND THE SE BASED SENSORS.

MTS® SENSORS DIVISION	A SIZE	DRAWING NUMBER APD-0035	DATE 9/23/97
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION B	ORIGINATOR RSM

Cross Reff. AP1-0014



NEMA 4 ENCLOSURE FOR TDU

MTS® SENSORS DIVISION CARY, NORTH CAROLINA	A SIZE	DRAWING NUMBER APD-0036	DATE 9/23/97
	SHEET 1 OF 1	REVISION B	ORIGINATOR RSM

MTS *APPLICATIONS (DISPLACEMENT) GROUP*
SENSORS DIVISION

Cross Reff. AP1-0015

FORMED TRANSDUCER SPECIFICATION SHEET

WE HAVE RECEIVED YOUR REQUEST FOR QUOTATION FOR A FORMED TRANSDUCER. IN ORDER TO PROVIDE YOU WITH AN ACCURATE QUOTE, WE NEED THE FOLLOWING INFORMATION. PLEASE COMPLETE AND FAX TO:

MTS APPLICATIONS (DISPLACEMENT) GROUP
919-677-0200

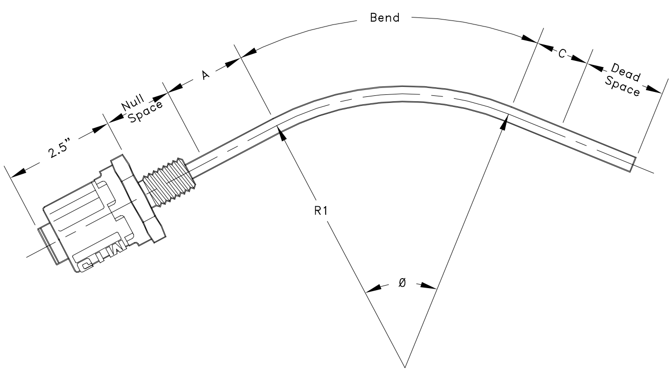
CUSTOMER:
CONTACT:
PHONE:
FAX:

REQUEST DATE:
RESPONSE NEEDED BY:

Null Space = 2.0" (Standard)
A =
Bend (Linear Length) =
C =
Dead Space = 5.0" (Standard)
ANGLE =
Bend Radius @ Pipe (R1)=
(Center of Probe) (minimum of 8 inches)

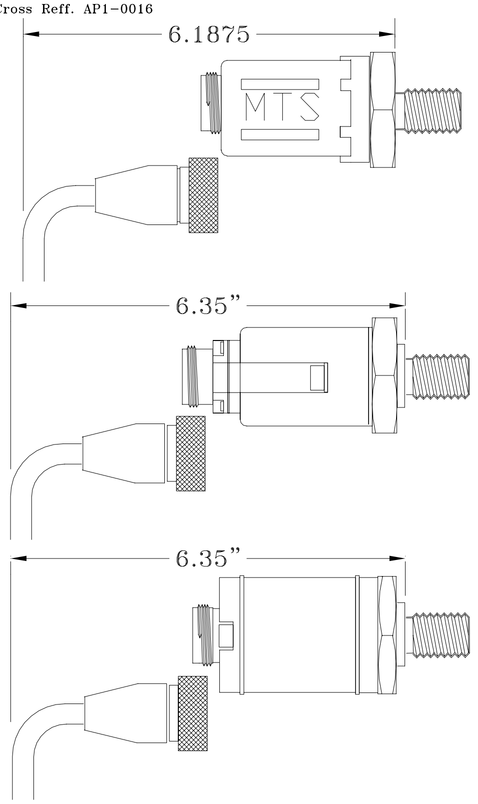
COMPLETED BY MTS

Style ______
Personality Modules ______
Connector ______
(tempo II style only)
Power Supply ______
Magnet ______
Extension Cable ______
Accessories ______
No Spring



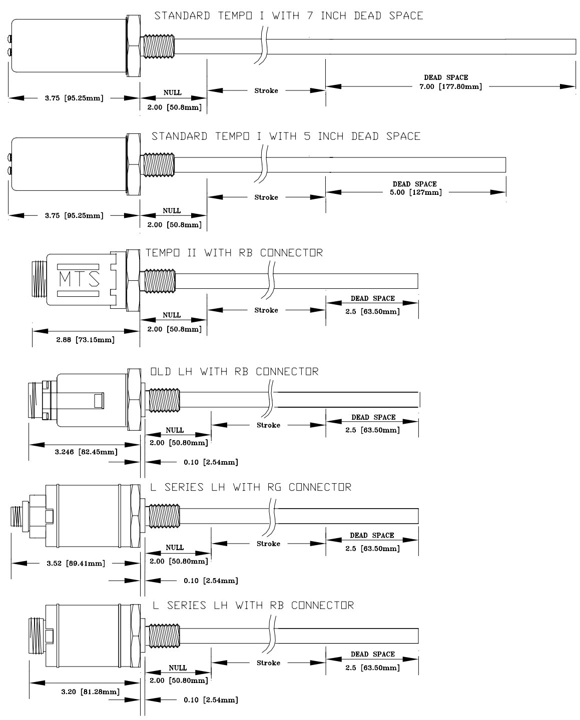
MTS® SENSORS DIVISION CARY, NORTH CAROLINA	A SIZE	DRAWING NUMBER APD-0037	DATE 9/23/97
	SHEET 1 OF 1	REVISION B	ORIGINATOR RSM

Cross Reff. AP1-0016



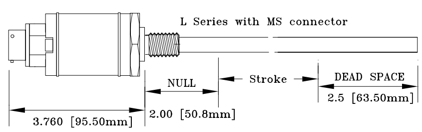
MTS® SENSORS DIVISION	A SIZE	DRAWING NUMBER APD-0038	DATE 9/24/97
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION B	ORIGINATOR RSM

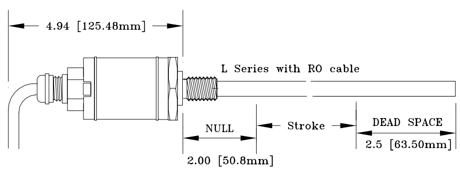
Cross Reff. AP1-0017



MTS® SENSORS DIVISION CARY, NORTH CAROLINA	A SIZE	DRAWING NUMBER APD-0039	DATE 9/24/97
	SHEET 1 OF 1	REVISION B	ORIGINATOR RSM

Cross Reff. AP1-0018





MTS® SENSORS DIVISION	A SIZE	DRAWING NUMBER APD-0040	DATE 9/24/97
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION B	ORIGINATOR RSM

SUBJECT: PLUG-IN ANALOG OUTPUT CARD WITH LP TRANSDUCER

OUTPUTS AVAILABLE: 0 TO +10 VDC DIFFERENTIAL (2 MAGNET)

FROM LP TRANSDUCER	WIRE COLOR	TO AOM PLUG-IN CARD CONNECTIONS
PIN 1	BLUE	N/C
PIN 2	GREEN	PIN 14
PIN 3	YELLOW	PIN 7
PIN 4	ORANGE	PIN 15
PIN 5	RED	PIN 5
PIN 6	BLACK	PIN 1

PIN #

1 DC GROUND
2 NOT USED
3 - 15 VDC INPUT
4 NOT USED
5 + 15 VDC INPUT
6 NOT USED
7 - INTERROGATION PULSE TO LDT
8 NOT USED
9 NOT USED
10 GROUND
11 GROUND
12 ANALOG DISPLACE. OUTPUT
13 NOT USED
14 + GATE FROM SENSOR
15 + INTERROGATION PULSE TO TRANSDUCER

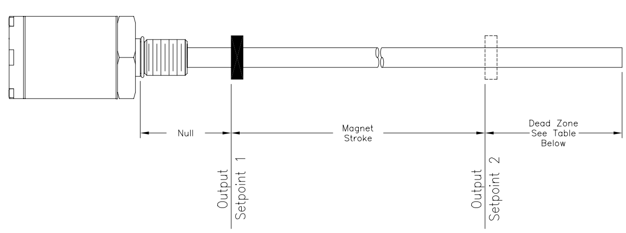
NOTE:

1. SHIELD WIRE (DRAIN) CAN BE CONNECTED TO PIN #1 ON THE AOM CARD.
2. PLUG IN CARD NOT COMPATIBLE WITH SE BASED LP. SEE APPLICATIONS.

REV B ADDED NOTE 2, DRAWING NUMBER CHANGED FROM MPDC-0030 TO APD-0041 TEP 9/26/97

MTS® Sensors Division	A SIZE	DRAWING NUMBER APD-0041	DATE 9/26/97
CARY, NORTH CAROLINA	SHEET 1 OF 1	REVISION B	ORIGINATOR R M PUTNAM

Use this page to specify custom analog setpoints utilizing single magnet systems with Temposonics



[ ] + [ ] + [ ] = [ ]

NULL
Must be
≥2.00" [50.8]
0.1" or 5mm
increments

Magnet Stroke
1.00" – 300.00"
[25 – 7600]
0.1" or 5mm
increments

Dead Zone
See table below

Total Tube
Length

Stroke Length	Dead Zone #1
2.0 – 197.0 [50 – 5000]	2.5 [63.5]
197.1 – 300.0 [5001 – 7600]	2.6 [66.0]

For longer Dead Zones please contact Application Engineering

Electrical Output

__.__ at Setpoint 1

__.__ at Setpoint 2

☐ VDC
☐ mA
(check one)

Non–Standard
Velocity (magnitude only)

☐ inches/second
☐ meters/second
(check one)

Notes:

1) Contact Application Engineering at 1–800–633–7609 for assistance.
2) Consult Application Engineering for model number when requiring custom setpoints.
3) Specify lengths in 0.1" or 5mm increments as applicable.

For MTS Personnel Only

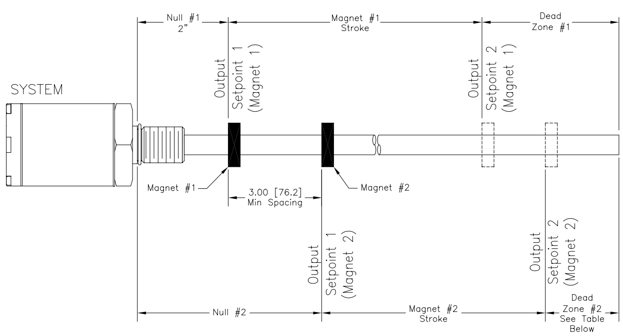
2.0" or 50.8mm + [ ] + [ ] + [ ] + [ ] = [ ]

Null | Additional Null | Magnet Stroke | Dead Zone | Additional Dead Zone | Total Tube Length

Application Eng ____________

MTS SYSTEMS CORPORATION SENSORS DIVISION, RESEARCH TRIANGLE PARK, NORTH CAROLINA 27709	DRAWING NUMBER APD-0042	DATE 1/12/00
	SHEET 1 OF 1	REVISION B BY KLP

Use this page to specify custom analog setpoints utilizing dual magnet systems with Tempo III RH series



NULL #1
Must be
≥2.00" [50.8]

Magnet #1 Stroke
2.00" – 300.00"
[50.8 – 7600]

All null and stroke measurements must be in increments of 0.1" or 5mm.

NULL #2 Must be at least 3.00" [76.2] greater than Null #1

\+

Magnet #2 Stroke 5.00" – 300.00" [127.0 – 7600]

\+

Dead Zone #2 See table below

=

Total Tube Length

Stroke Length	Dead Zone #2
2.0 – 197.0 [50 – 5000]	2.5 [63.5]
197.1 – 300.0 [5001 – 7600]	2.6 [66.0]

For longer Dead Zones please contact Application Engineering

Electrical Output

__ __.__	__ __.__	__ __.__	__ __.__
at Setpoint 1 (Magnet 1)	at Setpoint 2 (Magnet 1)	at Setpoint 1 (Magnet 2)	at Setpoint 2 (Magnet 2)

☐ VDC
☐ mA
(check one)

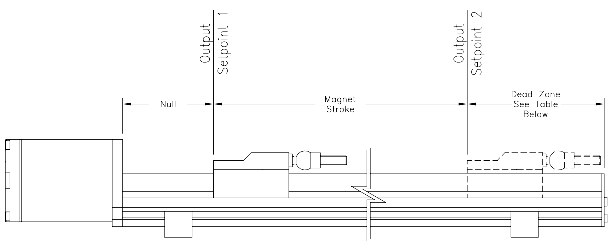
Notes:

1) Contact Application Engineering at 1-800-633-7609 for assistance.
2) Consult Application Engineering for model number when requiring custom setpoints.
3) Minimum magnet spacing between Magnets 1 and 2 is 3".

Application Eng. (Initials) ______

MTS SYSTEMS CORPORATION SENSORS DIVISION, RESEARCH TRIANGLE PARK, NORTH CAROLINA 27709	DRAWING NUMBER APD-0043	DATE 10/8/99	
	SHEET 1 OF 1	REVISION A	BY KLP

Use this page to specify custom analog setpoints utilizing single magnet systems with Tempo III PB series



NULL	+	Magnet Stroke	+	Dead Zone	=	Total Tube Length
Must be ≥2.00" [50.8] 0.1" or 5mm increments		1.00" – 300.00" [25 – 7600] 0.1" or 5mm increments		See table below		

Stroke Length	Dead Zone #1
1.0 – 196.0 [25 – 5000]	2.5 [63.5]

For longer Dead Zones please contact Application Engineering

Electrical Output

___.__ at Setpoint 1

___.__ at Setpoint 2

☐ VDC
☐ mA
(check one)

Non–Standard Velocity

☐ inches/second
☐ meters/second
(check one)

Notes:

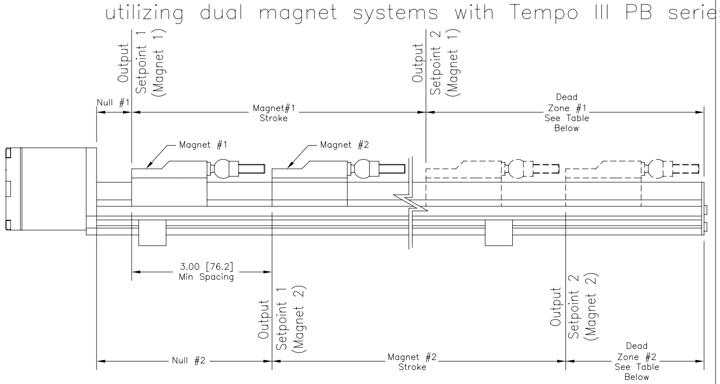
1) Contact Application Engineering at 1–800–633–7609 for assistance.
2) Consult Application Engineering for model number when requiring custom setpoints.
3) Specify lengths in 0.1" or 5mm increments as applicable.

Application Eng. (Initials) ______

MTS SYSTEMS CORPORATION
SENSORS DIVISION
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27709

DRAWING NUMBER	DATE	
APD-0044	10/8/99	
SHEET 1 OF 1	REVISION A	BY KLP

Use this page to specify custom analog setpoints utilizing dual magnet systems with Tempo III PB series



NULL #1 Must be ≥0.47" [12.0]

Magnet #1 Stroke 1.00" – 300.00" [50.8 – 7600]

All null and stroke measurements must be in increments of 0.1" or 5mm.

NULL #2 + Magnet #2 Stroke + Dead Zone #2 = Total Tube Length

NULL #2: Must be at least 3.00" [76.2] greater than Null #1

Magnet #2 Stroke: 4.00" – 300.00" [127.0 – 7600]

Dead Zone #2: See table below

Stroke Length	Dead Zone #2
2.0 – 197.0 [50 – 5000]	2.5 [63.5]

For longer Dead Zones please contact Application Engineering

Electrical Output

__.__	__.__	__.__	__.__
at Setpoint 1 (Magnet 1)	at Setpoint 2 (Magnet 1)	at Setpoint 1 (Magnet 2)	at Setpoint 2 (Magnet 2)

☐ VDC
☐ mA
(check one)

Notes:

1) Contact Application Engineering at 1–800–633–7609 for assistance.
2) Consult Application Engineering for model number when requiring custom setpoints.
3) Minimum magnet spacing between Magnets 1 and 2 is 3".

Application Eng. (Initials) ______

MTS SYSTEMS CORPORATION SENSORS DIVISION, RESEARCH TRIANGLE PARK, NORTH CAROLINA 27709	DRAWING NUMBER APD-0045	DATE 10/8/99
	SHEET 1 OF 1	REVISION A, BY KLP

APD-0046
Sensors Division

Title: Tempo 2 Manual Trim Procedure 1" (25mm) to 300" (7620mm) E.S.

Revision Notes:
A First Realease 07/07/00

Reviewed & Approved By: Mike O'Gorman

Tooling Requirements: Oscilloscope with dual trace and delay sweep capabilities (35 MHz bandwidth), Tempo 2 cable test set, Flat, smooth, non-magnetized surface, 2" and 3" gauge block, Resistor Decade Box, Hand Held Calculator, Felt Tip Pen and Resistor Lead Former.

CAUTION ! When the cover is OFF, the Tempo 2 transducer is a static sensitive device and should be treated as such. A Static Wrist Wrap or Heel Wrap must be worn during Testing.

Procedure:

1) The Model Number will specify the configuration, and electrical stroke of the transducer and output style. Connect the transducer to the Trim Station using the correct Tempo 2 cable test set. NOTE: the connectors on the transducer are pinned and keyed to a certain pattern and will go on only one way.

2) Connect the Decade box leads to the gain resistor hole on the Waveguide/Driver Amplifier PCB. Reference Figure 1.

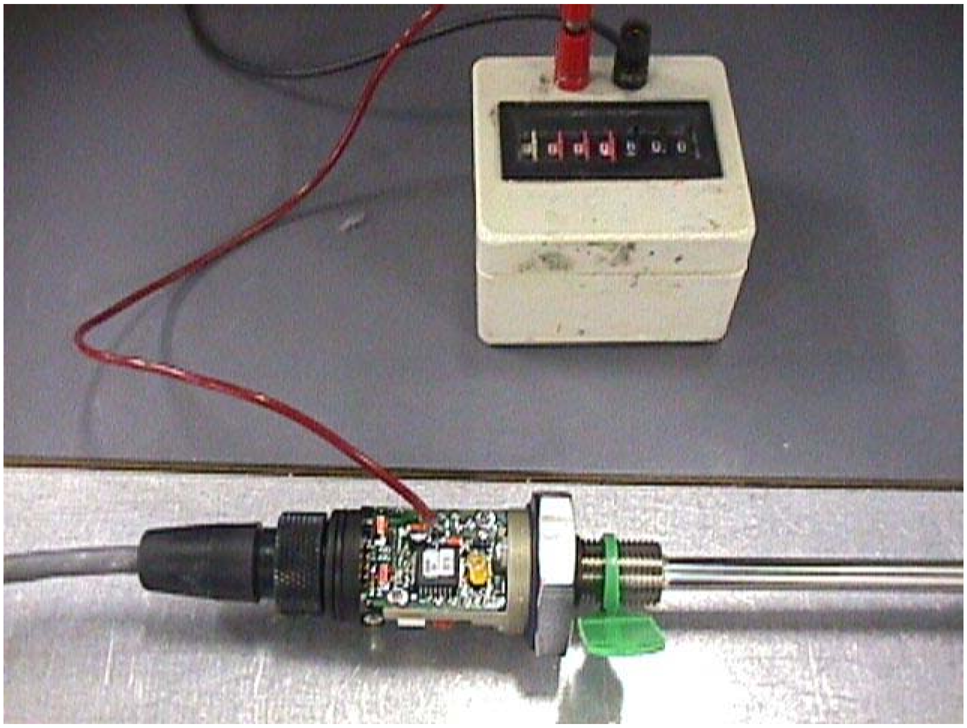


Fig 1

3) Be sure the oscilloscope is turned ON and the oscilloscope lead is connected to the test box. Adjust which ever channel the oscilloscope lead is connected.

4) Slide the Trim Magnet to within 2" of the hex. Reference Fig 2. Two signals like that shown in Figure 4 should be present on the oscilloscope screen.

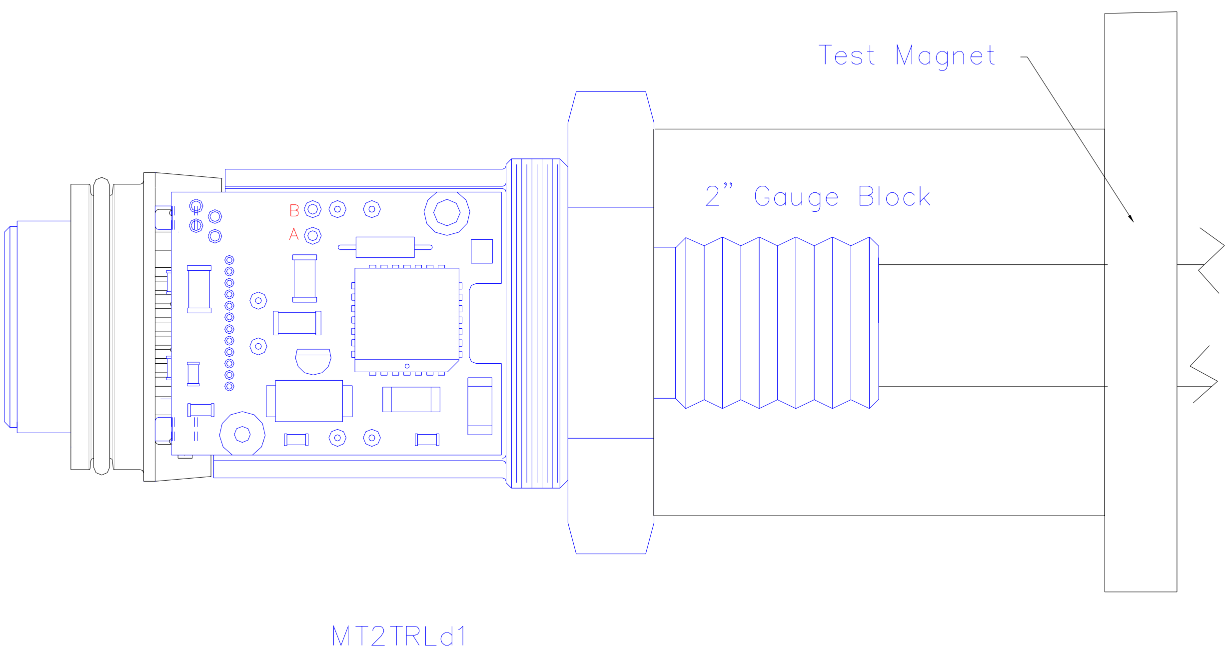


Fig 2

5) Slide the Trim Magnet to within 3" of the end of the transducer tip Reference Fig 4. Adjust the resistor decade box so that the *Vpeak MIN/MAX of the RETURN signal is in accordance with Figure 5 and Table 1.

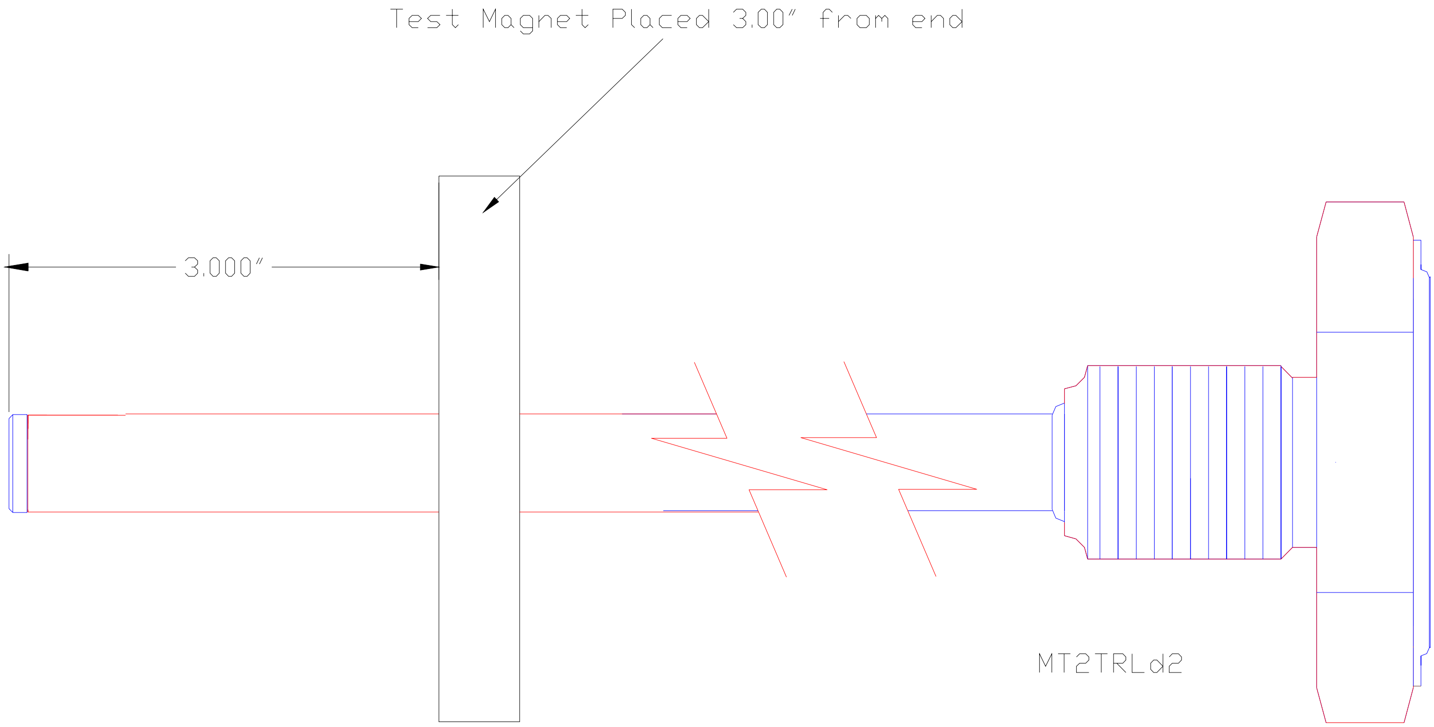
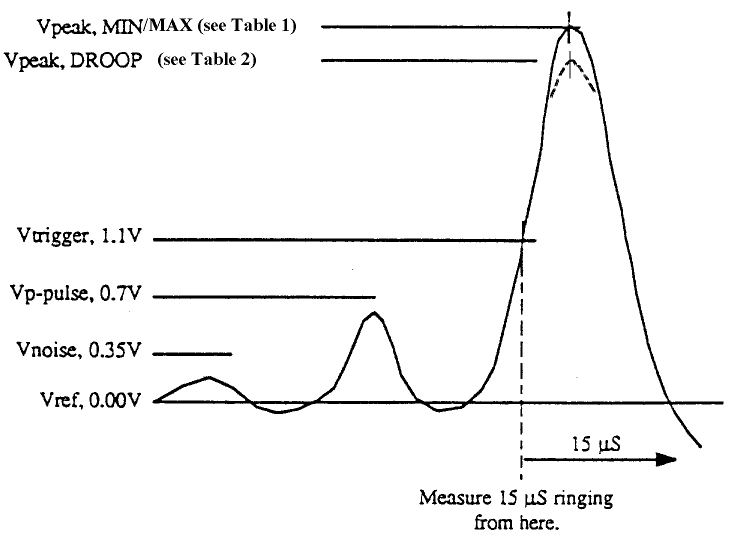
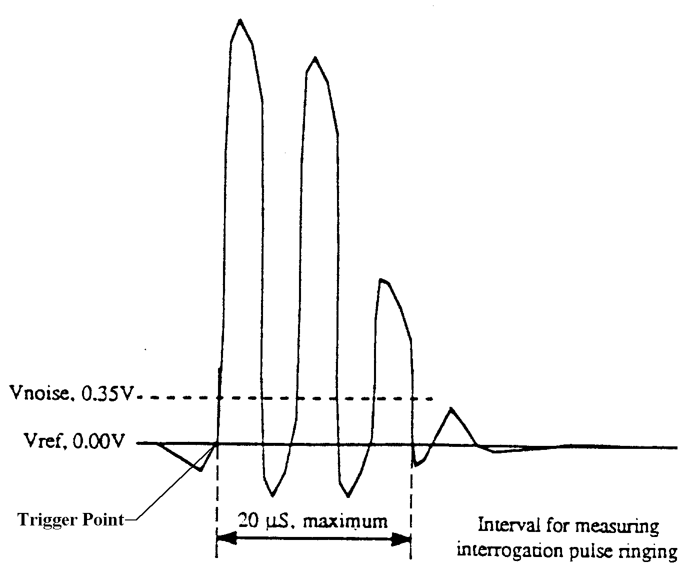


Figure 4.



Important test voltages on return signal. (signal.bmp)



(signal.bmp) Important test voltages on the interrogation signal.

Figure 5

Table 1

Version	Vpeak, MIN	Vpeak, MAX	Vpeak, DROOP	Vpeak, MAX along Stroke
1" (25mm) to 300" (7620mm) E.S.	2.20	2.70	2.20	4.20

6) Move the test magnet along the entire length of the waveguide so it comes to rest next to the. 2.000" gauge block as shown in Figure 2. Verify that

a) the return signal does not drop below the Vpeak (DROOP) level

b) the Vnoise level does not exceed 0.70V after 15 usec from the Vtrigger point on the return signal

c) the Vnoise level does not exceed 0.70V after 20 usec from the trigger point on the interrogation signal.

7) Read the display on the resistor decade box. If the value displayed on the resistor decade box is greater than the values noted in TABLE 2 for the stroke length being trimmed then the value is invalid and there is something "WRONG" with the.

Table 2 Maximum Allowable Trim Resistor Value

Electrical Stroke Length	Maximum Allowable Value in OHMS
180" (4572mm) to 300" (7620mm) E.S.	N/A

8) Turn the power to the transducer OFF. Solder a trim resistor (with a value that is within 5% of the value noted in step above into the Waveguide/Driver Amplifier PCB Reference Fig 6.

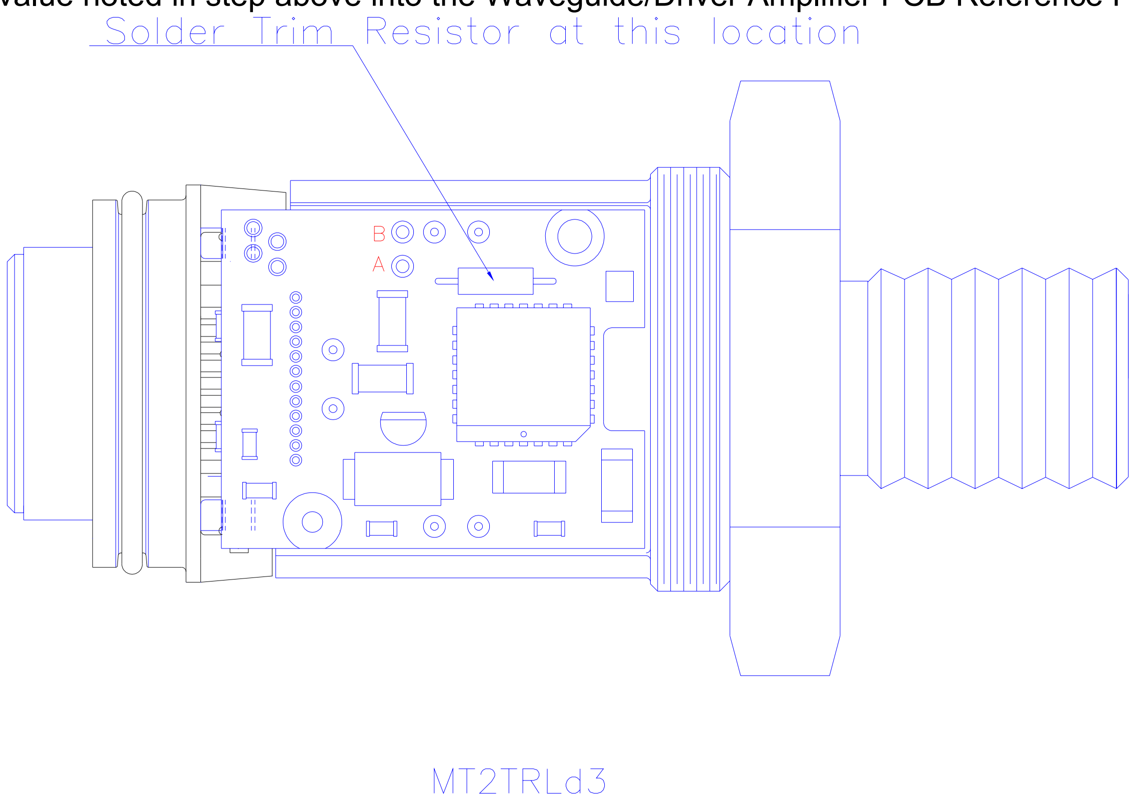


Figure 6

9) Turn the power to the transducer ON. Move the test magnet along the entire length of the waveguide. Verify that the return signal is still compliant to spec. Note: it is normal for the return signal to go above the Vpeak MAX level when the magnet is moved toward the HEX, BE SURE NOT to exceed the Vpeak MAX Along Stroke.

10) If the transducer meets all the requirements up to this point it is ready to have GRADIENT and LINEARITY TEST run on it.

APD-0048
Sensors Division

Title: Adjustment Procedure for the Set Slave Address Command for the Profibus P202 (Husky) Sensor

Revision Notes:
A Initial Release 12/13/01

Reviewed & Approved By: Uwe Viola

Purpose:

The purpose of this application note is to redefine the procedure for adjustment of the Temposonics R Series Profibus version P202 slave address in the field for transducer serial numbers 10123000 and above.

Restrictions:

For the Set Slave Address command we have the following restriction:

The Slave Address can **only be permanently stored** in the internal EEPROM after power up and before entering Data Exchange Mode.

Even if the sensor responds to the Set Slave Address Command and appears to be working with the new address, if the sensor was not taken out of Data Exchange Mode before programming, it will not retain the new address.

Procedure:

In order to program the sensor with a new address the following steps are required:

1. Make sure that the sensor is working under the expected address (default address is 126).

2. Leave Data Exchange Mode (change address of the projected slave in the actual configuration if necessary).

3. Restart your Profibus system (do not enter Data Exchange Mode).

4. Switch off and on the supply voltage for the sensor.

5. Change the Slave Address as in the normal procedure.